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ABSTRACT

This document provides an overview of the various telecommunications and information technologies available for rural communities to use in their health care systems. The first section explains the principal technologies of telecommunications such as the telephone, computer networking, audiographics, and video. It describes transmission systems that include microwave, coaxial cable, communication satellites, and optical fiber. Considerations for deciding on an appropriate transmission system are given. The next section examines programs in which telecommunication technology is applied to rural health care. Each entry presents the problem the technology addresses, the technology applied, and a program summary. Programs involve transmitting diagnostic material such as EKGs, X-rays, or ultrasounds; providing continuing education for health professionals; and allowing access to health-related databases, computer networks, or consultants. Statewide TeleHealth projects are also described. The final section provides a basic overview of some of the regulatory, legal, and quality assurance issues confronted by those implementing telecommunication systems, including legal and constitutional conflicts related to higher education delivered via telecommunications across state lines. This document contains 30 references, project and state contacts for further information, a glossary of telecommunications terms, and tables of transmission channels and compression standards and comparisons. (KS)

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Opinions expressed in this report do not necessarily reflect the views of the U. S. Department of Health and Human Services.

PREFACE

This document was prepared to assist rural communities considering the use of telecommunication and information technologies in their health care systems. It provides a simple and objective overview of the various technologies available and their rural applications. It also discusses the issues currently affecting the development and use of these technologies in rural areas.

Telecommunication and information technologies hold promise for the overall development of rural communities. Certainly they will play a key role in the development of health care networks under health care reform. They can decrease the isolation of rural health professionals -- promoting their retention and recruitment and even providing a way for rural communities to develop or "grow their own" health professionals. Telecommunication and information technologies can also improve and maintain the quality of care available in small communities by giving rural clinicians access to the latest biomedical information. Finally, such modern technology can enhance the range of the actual health services available locally, thus retaining health care dollars in the community.

Telecommunications can spell power and partnerships for rural communities. To tap its potential, however, local planners need objective information on the opportunities and options available. We hope this publication provides that information. Because the environment changes rapidly, and the number of telecommunications projects in the health field is increasing, the Office of Rural Health Policy has made plans to update this booklet within a year. Suggestions for improvements and revisions are welcome.

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INTRODUCTION:
TELECOMMUNICATION and INFORMATION TECHNOLOGIES AND RURAL HEALTH CARE

Many rural areas have very limited access to health care services. That's hardly news; the problem is to address the issue within the bounds of acceptable cost and available people and technology. The rural situation is not simply a low-population version of urban health care issues. A 1990 study by the Office of Technology Assessment (OTA) cited three problems that are specific to residents of rural areas:

- Although the rural population has relatively low mortality rates, a disproportionate number of rural people suffer from chronic illnesses. Furthermore, infant mortality is slightly higher than in urban areas and the number of deaths from injury are dramatically higher.

- The lack of a public transportation system and the existence of few local providers make it difficult for rural individuals to reach facilities where they can obtain care. Individuals living in areas with six or fewer residents per square mile, (i.e., frontier rural areas) have "geographical access problems of immense proportions." Moreover, in such counties there is often an insufficient population base to adequately support local health services.

- The OTA found that the physical barriers to access -- difficult as they are -- may be outweighed by financial barriers. In 1987 one out of every six rural families lived in poverty, compared to one out of every eight in urban areas. And, rural residents below the federal poverty level were less likely to be covered by Medicaid than urban residents (35.5 v. 44.4 percent).

Increasingly specialized and expensive medical technology and procedures make the access problem worse. The National Governors Association has reported that rural areas have less than half the physician coverage available in urban areas. Moreover, rural hospitals cannot afford to purchase limited use, state of the art technologies. As a result, these small community facilities find it difficult to compete with larger -- if more distant -- medical centers, and they are often forced to close. The U.S. General Accounting Office (GAO) has reported that half the community hospital closings during the 1980s were in rural areas. When those hospitals close, residents in the communities they serve lose an important entry point into the health care system. Meanwhile, many studies suggest that these rural communities may have disproportionately greater needs for health care than their urban and suburban counterparts, particularly in the area of emergency services. It has been estimated, for example, that about 60 percent of traffic fatalities occur in rural areas. In addition, rural residents are more likely to be engaged in hazardous occupations.

There have been many initiatives to address these issues of rural access, and an increasing number of them are relying upon telecommunication and information technologies to foster access. Everything from phone and fax to video and high-speed computing has been enlisted to provide specialty services, consultations and continuing education.

This report provides an introduction to the technologies related to telecommunications, and it shows how these technologies are being applied to enhance access to health care for people in rural areas.

A PRIMER OF RELEVANT TELECOMMUNICATION AND INFORMATION TECHNOLOGIES[1]

This section offers an introduction to the principal technologies of telecommunication, pointing out their main characteristics, a bit of history, and some elements of cost.

There are two broad divisions: the media of telecommunication (the telephone, video, computer, etc.) and the means of transmission (phone lines including optical fiber lines, satellites, microwave systems, etc.).

The media -- telephones, video cameras and monitors, fax machines, computers, etc. -- might be considered the input-output devices of the system: we use them to send and receive voices, pictures, text, diagnostic images, and sounds. The means of transmission actually carry the products of these media, i.e., the words, pictures, etc., from sender to receiver.

A note about costs: Firm dollar amounts are not used here because in key areas they change too rapidly for references to be useful over the lifespan of a publication like this. A typical pattern finds prices dropping dramatically as new products and services find acceptance. For example, today's computers are increasingly powerful and relatively cheap because the main elements of computing -- processing and memory -- have had price reductions of about 50 percent every three years for the past 40 years! The result is not only that we do familiar tasks less expensively, but that the underlying technology can be applied in new ways, setting off yet another round of innovation with cost implications rippling in all directions.

In spite of the frantic pace of innovation, however, it is possible to understand the technological menu and make sensible choices.

A preliminary note: While this is certainly not a technical treatise, even the most technophobic among us eventually must confront two key words, used so often that understanding them makes it far easier to follow the menu. They are "bandwidth" and "digital."

---

[1] For readers new to the terminology of telecommunication and information technologies, a glossary of terms has been developed. It includes terms used in this document, as well as terms readers may come across in future readings on the topic.

1. Bandwidth. Bandwidth is simply a measurement of a telecommunication channel's capacity, "the size of the pipe." The necessary bandwidth varies with the amount of information to be transmitted. For example, an AM radio station located at 600 KHz on your dial actually occupies the band between 595 and 605; it needs a bandwidth of 10 KHz in the electromagnetic spectrum where broadcasting takes place. (KHz means kilohertz, or thousand hertz. A hertz is one wave cycle per second.) A telephone needs only to handle the sound of a voice; it is designed for a bandwidth of four KHz. A television station, transmitting moving pictures as well as sound, needs a bandwidth of six megahertz (6 MHz or 6 million hertz).

Channel capacity -- bandwidth -- is sometimes expressed also as the number of bits (or sets of bits, called bytes) per second that the channel can handle. (A bit is a "unit of information" in a computer-based binary number system.) One might be tempted to assume that each of a television channel's six million wave cycles per second could carry the off-or-on message of one bit, and therefore six megahertz would equal six megabits (six million bits per second or 6Mbps). But in fact there is no fixed relationship between a hertz and a bit. Today a bandwidth of six megahertz commonly carries between three and ten megabits. Digital technology holds both imperatives and opportunities for those who use it to encode information. It will be seen below that some of this coding magic is making possible major economies and efficiencies in the transmission of video.

The important parts of all this are:

- The more information that must be sent (sound, pictures, bits of information) the more bandwidth that is required. Moving images take more bandwidth than still images; color takes more bandwidth than black-and-white.

- Bandwidth costs money. The greater the bandwidth, the higher the cost.

2. Digital and analog. When you turn on your car radio, you hear the result of a process that draws an electronic picture -- makes an electronic analog -- of the frequencies and relative volume of the original sound. If you were to look at that picture on an engineer's oscilloscope, you would see a pattern of wave forms marching across the tube. Morse's telegraph, on the other hand, encoded words through a pattern of clicks formed by switching electric current off and on very rapidly.

Today's digital technology has more in common with Morse's telegraph than with the radio station's electronic wave forms. Digital coding, represented by zeros and ones, is actually an elegantly simple process of encoding information by turning the power off and on. A bit -- a zero or one in the coding scheme -- is simply the presence or absence of a minute amount of power during a very small interval of time.

The world is rapidly moving toward digital systems for everything from telephones to television. The reasons are straightforward:

- Since digital systems reduce all kinds of information (sound, pictures, data) to off-on bits, it is possible to send different kinds of information simultaneously through the same channel.

- Digital systems can use transmission channels more efficiently than can analog systems.

- Digital systems generally reproduce information more accurately, thus providing users with higher quality than analog systems can handle.

There are cost implications in both directions. Since digital systems can use transmission channels more efficiently, transmission costs may go down. But since digital systems can be quite complex, the necessary equipment may be more expensive. One handy example: in order to realize the economies of digital video, one must buy a codec. At the receiving end of the system, a codec converts the incoming digital video signal back to analog so that your analog television set can display it. Codec is a contraction for COde-DECode. A computer modem (MOdulate-DEModulate) performs similar duty in allowing you to send your computer's digital messages via an analog phone line.

On balance, digital technology has much to recommend it in spite of these complexities, and the world is moving strongly toward digital systems.

The implications of these two concepts -- bandwidth and digital/analog -- will become apparent as we consider specific technologies in the sections to follow.

The Media of Telecommunication

The Telephone: An old friend learns to fly

The telephone, patented just 40 years after Morse's telegraph (in 1876) is easily the most important telecommunication device ever created. Sometimes overlooked as a little old-fashioned for today's high-tech telecommunication projects, the telephone has some major advantages:

- Ubiquity. Virtually everybody has one. Universal telephone service has been a goal of public policy in the United States for 60 years.

- Relatively low cost. The cost of basic installation has often been covered, the telephone is a narrowband instrument (doesn't use much bandwidth), and training time is minimal even when new applications are envisioned.

- Cost per-use is low because system costs are spread among an enormous number of users.

The telephone is a lot more than what the industry calls POTS: Plain Old Telephone Service. It can be applied very flexibly because of the range of services which have emerged during the past few years. These include:

- Conferencing, in which relatively large numbers of people, geographically dispersed, can meet together by phone. A device called a conference bridge makes it possible to interconnect the participants and maintain good technical quality. For those whose conference requirement is infrequent, it is usually best to contract with a conference service for the bridge and operator support.

- Voicemail, for the transmission of voice messages when instant response is not required. The basic "answering machine" sort of voicemail can be extended to provide mailboxes for project participants or, for example, to send a voicemail message simultaneously to members of a defined group.

- Fax, for the transmission of material on paper via the telephone system. Initially developed half a century ago, fax has become nearly ubiquitous as the perceived need for the service coincided with the application of cost-saving microelectronics plus the economies of volume manufacturing.

- Computer communication, which uses the phone system -- and perhaps other networks -- to exchange electronic mail, transmit documents (and an increasing variety of other things), and engage in electronic conferencing. See the next section below.

- And picturephones, which transmit a picture of those talking, have been a perennial "just around the corner" technology but may be coming closer to everyday use.

Computer Networking: the Number-Cruncher as Communication Device

One of the fastest-growing areas of telecommunication is communication by computer. There are two complementary applications: electronic mail and computer conferencing.

As its name implies, electronic mail allows the user to address a message to another person or to a group. The message is usually in text form, but system advances make it increasingly feasible to send pictures, charts and diagrams, and sound as well. The message is held in the recipient's electronic mailbox -- located in a network node computer, rather like your local branch post office -- until the recipient dials in and collects it.

Computer conferencing uses some of the same techniques as electronic mail, but it can best be described as an online conference in which the participants are not expected to be present at the same time. Conferences are organized by topic. When a participant dials in, he/she can read what colleagues have contributed, then add related comments as appropriate. At first glance the topic-and-reply format may strike one as a bit rigid, but in fact conferences can be organized in many ways and provide a surprisingly personal and flexible means of communication within a group.

Electronic bulletin boards fall somewhere between conferences and electronic mail. Users may read, post or respond to messages on a "bulletin board" organized by topics.

The Internet. For those in education, government, and research, the most common network for computer communication is the Internet, the largest computer network in the world. The Internet is actually a network of networks, involving the National Science Foundation's NSFNet and a huge complex of university system networks and other networks related to research and government. The proposed National Research and Education Network (NREN), currently known as the Interagency Interim National Research and Education Network (IINREN) will vastly increase the size and capability of today's Internet. Because of the federal government's financial investment through the National Science Foundation, there are currently a number of Congressional bills that aim to put into place a national information infrastructure, referred to as NII. NREN related activities would be encompassed by this NII.

In addition to providing major communication capabilities, the Internet is the venue for a huge amount of information stored in accessible databases. At present the use of the Internet appears free to the end user because the costs have been covered by affiliated institutions and the system is organized so that costs are not, like phone charges, usage-sensitive. This may change in the future, however.

Several other networks are available to computer users, including such diverse systems as MCI Mail and the Prodigy service. Not all networks support all services (particularly conferencing), but each has its strength. Most have usage-sensitive pricing, which can quickly discourage database browsing, not to mention online schmoozing.

Audiographics: Multimedia on a Budget

Think of it as an illustrated lecture: the lecturer's voice is transmitted along with quick chalkboard-like sketches, diagrams, etc., to which students can respond either orally or via an electronic sketch pad. The combination is sent via telephone technology. The result is a system that offers the flexibility of voice-plus-visuals at a cost far below that of most video-based systems. Furthermore, these systems are becoming much more powerful and flexible as the graphic capabilities of computers are brought to bear. In a typical application, a course or meeting conducted from a central location involves participants at one or several remote sites.

Video: Ringside at the Revolution

For many of its pioneers (from not so many years ago) today's video technology must be scarcely recognizable. The pictures we see at home haven't changed much for most people, but the underlying technology is in the midst of a revolution, with significant implications for users such as the health care system, education, and business. Following are some of the important variations.

Full-motion "broadcast" video. This is the video you usually see when you turn on the set at home. There's an enormous amount of information in every frame: in the U.S., 525 lines of video are scanned 30 times a second to reproduce the colors, brightness, and motion of the original. The result consumes an impressive amount of bandwidth: each television station in the U.S. is allotted six MHz (the bandwidth allocated for all the FM stations on your dial would accommodate only three television stations). When this broadcast-standard video is networked by satellite it commands a significant share of the satellite's total capacity. As noted above, bandwidth is expensive.

Compressed video. A major development of the 1980s was the marriage of telecommunication and computing. One result was the application of digital technology to video. That makes it possible to take a fresh look at how video pictures are made. No longer is it necessary to scan every colored dot of all 525 lines 30 times a second in order to make a picture. Using digital technology it is possible to send only those portions of the picture which change frame-to-frame, plus a code that tells the system "Play it again, Sam" for those portions of the picture that don't change. Furthermore, not every application requires 30 frames per second in order to have useful video. The resulting efficiencies can be dramatic. While a conventional six MHz television signal commonly has been translated to a digital format of approximately 45 megabits per second (45Mbps), compressed video for telemedicine consultations is being transmitted at 1.544 Mbps (and in some cases even lower). Compressed video for some business and educational applications is being transmitted at 56 kilobits per second (56 thousand bits versus 45 million bits!).

So while the initial cost of the digital technology is higher than for conventional analog video, the bandwidth requirement is much less, which means that transmission costs can be reduced dramatically. For many applications, video of good quality becomes affordable.

As further advances are made in compression technology, we can expect video of good quality to require even less bandwidth. For many applications we already see video transmitted over lines the phone companies have labeled T1. A T1 line has a bandwidth of 1.544 Mbps; i.e., it can transmit 1.544 megabits per second. The key lesson is that one should no longer assume that video is too expensive.

Interactive video. Given the economies of compressed video, plus the smaller, less expensive video equipment now available, it is now common to have two-way video links for teleconferences, education, and comparable applications. Participants at multiple sites can see and hear each other during the event. Costs for such a service can be very attractive. In the Oregon ED-NET system, for example, multi-site interactive video has an hourly transmission cost that is approximately one-fifth that of one-way "conventional" broadcast-standard video.

Interaction doesn't necessarily imply two-way video. Some systems are based on one-way video with voice return (often by telephone), or a return channel that carries information from a keypad, computer, graphics tablet, etc. This technology can be expected to evolve rapidly and cost less as it is applied to such consumer applications as interactive game shows, shopping channels, etc.

Slow-scan video. Slow-scan, or still-picture video is a method of providing transmission of still pictures over conventional phone lines. As demonstrated above, motion needs substantial bandwidth, and for many applications the cost of that much bandwidth is unacceptable and/or transmission of motion is not necessary. Slow-scan video trades bandwidth for time: it can yield good picture quality over an ordinary phone line by stretching out the time it takes to send the information. Rather than 30 frames of moving video per second, a slow-scan system may take several seconds to more than a minute for a single frame, depending on the quality desired. Slow-scan video has been used successfully for transmission of X-ray images and other diagnostic imaging, using ordinary twisted-pair copper phone lines and the bandwidth of an ordinary phone call.

A variation of slow-scan video provides computer-to-computer transmission of similar images.

The Means of Transmission

Introduction

In designing a telecommunication system for rural health care or comparable specialized applications, the basic questions are:

- How many sites must be reached?
- Where are they? How far from the "headquarters" location and from each other?
- What potentially useful facilities already exist, e.g. telephone lines, cable TV, satellite send/receive facilities, microwave systems, fiber optic trunks for cable TV or telephone, or a private or government carrier?
- What is the nature of the information to be transmitted: video, audio, computer data, etc.? What are the givens concerning media and equipment to be used (existing video studios, computer facilities, etc.)?
- How much information is to be transmitted at a given time (i.e. what is the bandwidth requirement?)
- How much interaction is required, and where are those who must interact?
- What are the practical financial limitations? What are the priorities separating "must have" from "nice to have"?
- How long is the project intended to last?

Answers to these questions lead to tradeoffs about the technologies to be applied.

The Telephone Network (AKA the Public Switched Telephone Network - PSTN)

The world's fundamental telecommunications network is the phone system, which is designed primarily for voice and data. Its long-haul links have very high capacity -- increasingly based on optical fiber -- but the system is built primarily around the narrowband requirements of the telephone, plus other technologies (fax, computer modems) that can be made compatible with the characteristics of the ordinary phone. Twisted copper pair wiring remains the foundation of the local system.

A key characteristic is that this is a switched network. Each user has an address (the phone number) and the system is designed to route a call originating from any point on the network through a sequence of switches to reach the specific number being called. Most cable television systems, on the other hand, are distribution networks intended primarily to deliver programs from a central point to subscribers.

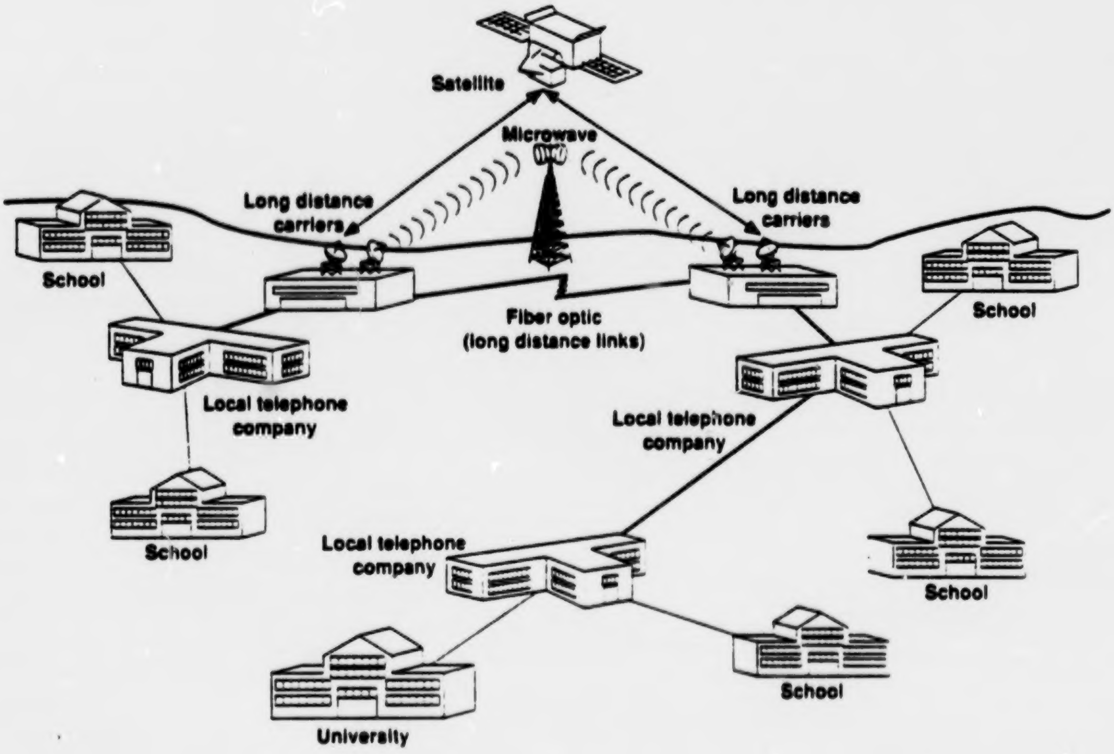
To many, Alexander Graham Bell and his colleagues seemed hopelessly visionary when in the 1870s and '80s they were describing telephone systems that would extend through cities much as the network of gas pipes did then, or when Bell predicted that businessmen would use the telephone to speak with "their agents a hundred miles away" as conveniently as they called their servants via their familiar household speaking tubes.

Mr. Bell and his successors were perhaps too modest in their projections. Consider some of the characteristics of the present-day telephone system:

- It is ubiquitous, extending virtually everywhere in the industrialized world and building rapidly elsewhere.
- Service is relatively inexpensive.
- It is a genuinely public network.
- The switched network configuration permits any two points in the system to be connected directly and virtually instantaneously.
- The system is growing rapidly in capability with advances in fax, data communication, and other technologies described above.

The phone system is an increasingly flexible resource. The switched telephone network has grown far beyond its "twisted copper pair" image. The phone companies are major users of optical fiber as well as high-capacity copper cable, they pioneered satellite communication, and they remain among the heaviest users of microwave systems. While we generally think of phone company services as narrowband, as noted above, these carriers commonly offer higher-capacity channels such as T1, which can transmit 1.544 megabits of information per second -- enough for many video applications. (see comparison charts, page 79)

Figure 1--The Public Switched Telephone Network


Satellite
Microwave
Long distance carriers
Long distance carriers
School
Fiber optic (long distance links)
School
Local telephone company
Local telephone company
School
Local telephone company
School
School
University

The public switched telephone network uses many technologies to connect subscribers near and far. Although used primarily for voice services today, in the future the public telephone network may become more a public information network, capable of carrying conversations, computer communications, and video programming.
SOURCE: Office of Technology Assessment, 1989.

At this writing the phone system of the United States consists of 22 Bell operating companies, several major independent telephone companies such as GTE, about 1400 smaller independent companies, and as many as 500 long distance companies.

The system is undergoing great changes, with more companies offering more services under a relaxed regulatory scheme, resulting in unprecedented ferment and innovation. The traditional rivalry between the telephone and cable TV industries is becoming a wary search for mutual benefit. America's future telecommunication system will be based on an integrated approach to voice, video, and data, with much more interaction by the user. Today's most fundamental trends are:

- The move toward wireless telephones and cellular systems. It is often predicted that the telephone system of the future will appear wireless to the user, with high-capacity cable trunks providing the infrastructure between wireless phones and terminals.

- The move to digital technology. This marriage of telecommunication and computing has several effects:

    a. It makes telecommunication systems much more versatile and flexible. Modern voicemail systems, for example, are possible because of digital switching and recording.

    b. It makes telecommunication systems more efficient, with resulting cost savings.

Case in Point: ISDN

Telecommunication users will be hearing much more about the Integrated Services Digital Network (ISDN), which is a practical application of the fact that to a digital transmission system, anything that can be sent is just a stream of off-on bits. In ISDN systems a variety of services can be sent through a single channel simultaneously, using a sort of mix-and-match coding that permits voice, data, etc., to be sorted out at the receiving end.

There are different sorts of ISDN interface, with varying capacities. Broadband ISDN (B-ISDN) is for users who need to handle large quantities of data, voice, and video simultaneously. Basic narrowband ISDN combines voice and relatively low-speed data. Primary narrowband ISDN can combine voice, data, and video at a bandwidth equivalent to a T1 channel. As might be expected, B-ISDN involves much more complexity in routing the various information streams to their intended destinations. As in many other areas of digital technology, however, distinctions and difficulties tend to blur as equipment evolves at an ever-increasing pace.

High Capacity (Broadband) Networks

Although the telephone system uses all the high-capacity transmission technologies, most people think of it as a narrowband service because of its historic emphasis on voice and compatible services, which are relatively undemanding consumers of bandwidth.

In this section we review the transmission technologies generally considered broadband. That is, they can carry a lot of information and often are associated with such voracious consumers of bandwidth as video.

In a rough order of capacity, they are microwave, coaxial cable, communication satellites, and optical fiber.

Microwave. Terrestrial microwave is a workhorse for relatively short-range wireless communication. Its distinguishing characteristic is that send and receive locations must be in line of sight. In the days before satellites and optical fiber (and not uncommonly today), transcontinental telephone and broadcasting networks marched across the continent via microwave repeater stations, mountaintop-to-mountaintop. Within urban areas microwave systems relay signals of all kinds point-to-point, located on convenient buildings or hills. The amount of bandwidth available varies from system-to-system, and depending on the application may be referred to customarily in megahertz or megabits. A common phone company microwave system has a bandwidth of 45 Mbps. Known as a DS-3 system, it can carry 672 phone lines or 28 T1 circuits. A local FM station relaying its programming from a downtown studio to its mountaintop transmitter may use a single-channel microwave system of 150 KHz. Suffice it to say here that microwave systems can be designed to meet widely varying requirements, digital or analog, and voice, video, or data.

ITFS. While the typical microwave system is highly directional (point-to-point), some varieties are intended to reach many locations (point-to-multipoint). During the 1960s such a microwave allocation was made to American education for the distribution of instructional television programming. In federal jargon it's known as the Instructional Television Fixed Service (ITFS), and a given educational licensee may use as many as four "conventional" six MHz channels. ITFS systems operate in the frequency band around 2.5 GHz (Gigahertz, or billion cycles per second), not far from UHF (ultrahigh frequency)[2] television stations.

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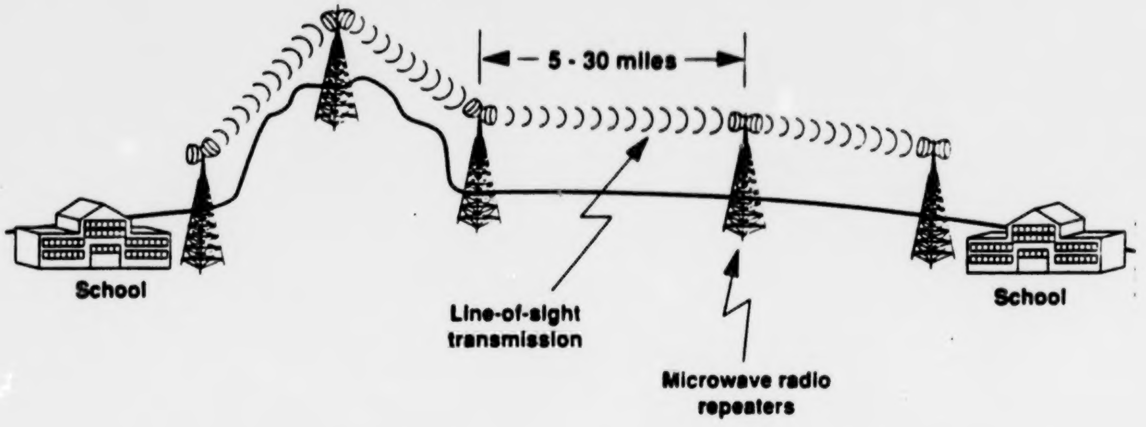
[2] The sixty-eight channels available for broadcasting in the United States and Canada are divided into two groups -- very high frequency (VHF) channels [2-13] and ultrahigh frequency (UHF) channels [14-69].

Figure 2--Microwave Communication System



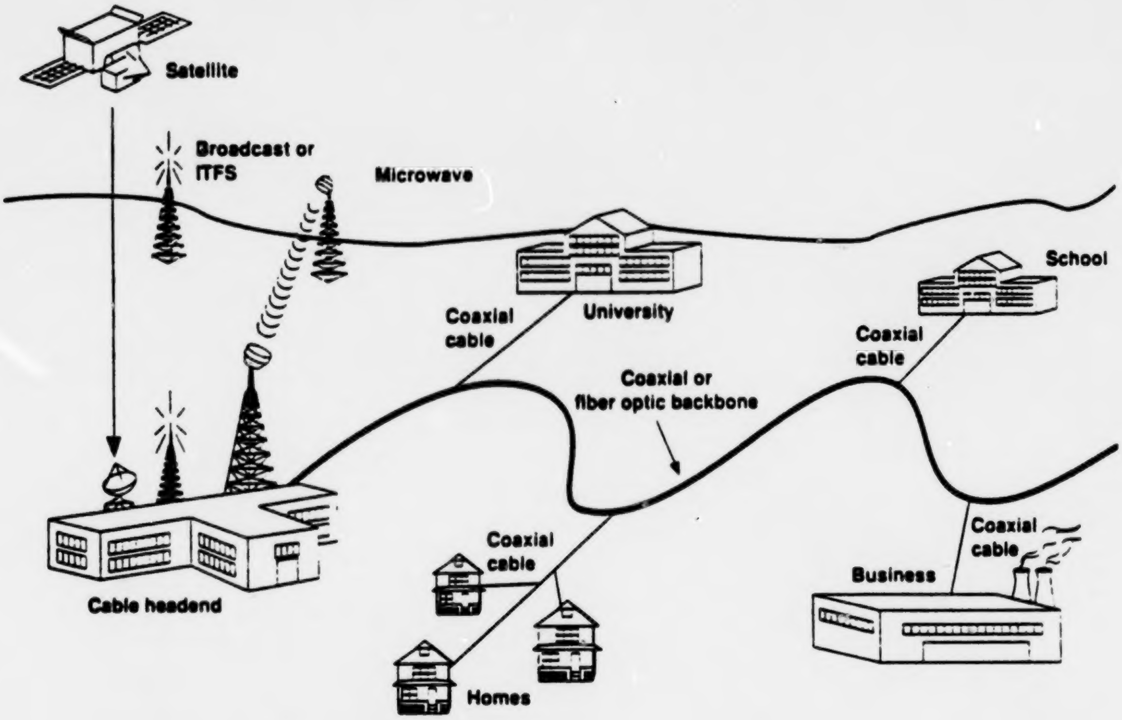
SOURCE: Office of Technology Assessment, 1989.

MMDS. The technology of ITFS is used also by the so-called wireless cable systems which offer television to home subscribers. This variation is known as Multichannel Multipoint Distribution Service (MMDS). Some MMDS systems in fact operate on the channels reserved for ITFS, through arrangements with local educational agencies.

With the advent of compressed video (described above) it is possible to fit multiple channels of video into the bandwidth previously required by one. As technology advances, that multiple keeps going up; at this writing it's possible to fit four to six channels into each "basic" channel.

Coaxial Cable. The technology used to send 30-to-50 channels of television into most American households is coaxial cable. The meaning of its name is clear if you examine a cross-section: a central conductor of copper approximately as thick as a pencil, a donut of insulating material, then another ring of conductor, and finally an insulating cover. This design enables the cable to handle much more bandwidth than ordinary twisted-pair copper wire, thus making multichannel cable television feasible. The capacity of any transmission system is gradually diminished as the signal travels over distance, and so systems are designed with amplifiers that boost the strength of the signals periodically. As is the case with all transmission media, the workable bandwidth available in coaxial cable systems is partly a function of the distance between amplifiers.

Figure 3--Cable Television Distribution System


Satellite
Broadcast or ITFS
Microwave
University
School
Coaxial cable
Coaxial cable
Coaxial or fiber optic backbone
Coaxial cable
Coaxial cable
Business
Cable headend
Homes

Programming from many sources can be redistributed through a cable television distribution system. Schools can receive educational programming through the local cable company and some systems can also be used for two-way communication between schools.
SOURCE: Office of Technology Assessment, 1989.

Incidentally, some people assume that coaxial cable is essentially a one-way medium, since most of us can't send signals back upstream from our television sets. In fact, this characteristic is simply a result of the fact that most cable companies (until recently, at least) have perceived themselves to be in the video distribution business, and thus have had no need for amplifiers that work in both directions. The limitation, then, is the amplifier and not the cable.

Communication Satellites. In the mid-1940s Arthur C. Clarke wrote an article that appeared in the journal *Wireless World*. It was called "Extraterrestrial Relays: Can Rocket Stations Give Worldwide Radio Coverage?" He described an orbit, 22,300 miles over the equator, where an object -- a "man-made moon" -- would appear fixed over a point on the earth's surface, neither rising nor setting. From such a position the object could "see" more than a third of the earth. If one could put a relay mechanism of some kind in that orbit, it would make possible instantaneous communication between virtually any two points over a third of the earth. If one could put such an extraterrestrial relay over each of the world's three great oceans, telecommunication could be virtually live, real-time, from nearly anyplace to anyplace on the planet. Furthermore, Clarke pointed out that during World War II the Germans had made great strides in rocket propulsion. With continuing advances in rocket technology such an orbit, he believed, soon would be achievable.

When he wrote his article, Arthur Clarke did not believe that his vision of communication satellites would be realized within his lifetime. But he hadn't counted on the invention of the transistor and the dawn of the microelectronics age, just a couple of years later. At this writing Arthur Clarke is alive and well, and satellites ring the earth precisely in the orbital positions he prescribed.

The communication satellite is a relay station in space. The pioneers in the field were microwave engineers. Accustomed to relays from mountaintops, they adjusted their calculations to design systems with a "mountain" 22,300 miles high, beyond our protective atmosphere in the vastness of space, with electric power provided by solar cells and batteries.

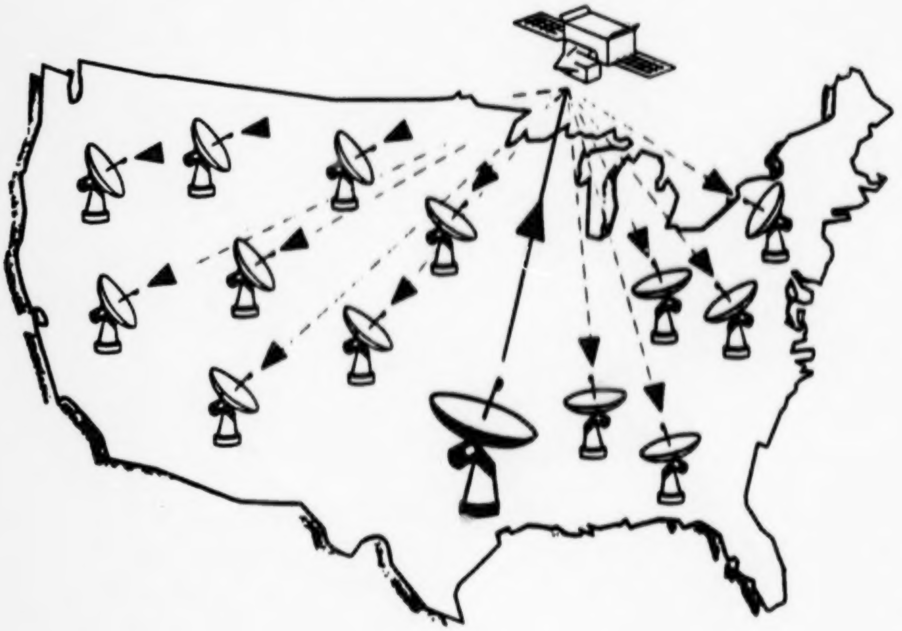
Like other broadband transmission technologies, a satellite can handle voice, video, or data. Satellites are now the prime carriers of broadcast and cable networks, and they are used increasingly for teleconferencing, delivery of course material, and other specialized purposes. While they are used in many telephone and data systems (much of the international traffic goes via Intelsat, the international satellite system), they introduce an annoyance: while their signals travel at the speed of light, the round trip of nearly 45,000 miles takes almost a quarter-second -- enough to disrupt the rhythm of normal conversation and an eternity to a computer's processor.

Satellites are designed with multiple channels of transmission. Within a satellite the fundamental relay device for a channel is the transponder. In many present-day satellites a transponder is equated with a video channel; for services demanding less bandwidth a transponder may be subdivided as necessary. With the advent of compression techniques, however, it is becoming possible for a transponder to handle multiple video channels simultaneously, thus dramatically reducing the cost per channel. In the past, a typical satellite had a dozen transponders, each with a bandwidth of 36 MHz, and a television channel took a full transponder. With today's compression technology, each transponder might handle four to eight channels of television, and even higher compression ratios have been announced.

Satellites also have ingeniously designed antennas, so that their transmissions may be focused on a given continent, country, or even a time zone or metropolitan region. Furthermore, focusing on a smaller footprint (as the coverage area is called) has the effect of increasing the power of the signal in that area, just as a flashlight's reflector increases the amount of light within a smaller area.

The familiar dish antennas that receive satellite transmissions collect energy radiated from the satellite, focus it on a central point, and deliver it to its destination. This antenna is also called an earth station or, not quite correctly, a downlink. Its diameter depends on the amount of energy that must be collected, and thus a signal of higher power can be handled by a smaller antenna. An earth station designed only to receive signals is of course much less expensive than one which also transmits (an uplink), and an earth station receiving simple analog television (like the typical backyard dish) is less expensive than the equipment necessary to handle compressed digital signals.

Figure 4--Satellite Communication System



Satellites can deliver educational programming and courses to schools across the country. Video programming and text materials are broadcast from a central origination site (uplink) to any school with a satellite receiver (downlink).
SOURCE: Office of Technology Assessment, 1989.

Satellite users find themselves in discussions of C-band and Ku-band satellites. These terms refer to the frequencies used: C-band satellites operate at lower frequencies than Ku-band spacecraft, 4/6 GHz vs. 11/14 GHz (a gigahertz is a billion wave cycles per second). These designations are also related to the services that carriers may offer with a given satellite.

Satellite systems have these principal characteristics:

- Within the footprint of the satellite they can be received virtually anywhere. It's simply a matter of installing an earth station. Thus, these systems are very flexible.

- For practical purposes, within the footprint of the satellite any transmission goes the same distance: 22,300 miles up and 22,300 miles down. Thus, charges are based on the amount of time and satellite capacity used in a transmission, and not on the distance between terrestrial points.

It should be acknowledged that satellites have a wide range of applications other than communication, including navigation, environmental and weather observation, military surveillance, etc.

Optical Fiber. If there is a glamour technology in telecommunication today, optical fiber is it. In addition to its relative novelty, there are some impressive reasons why:

- Optical fiber offers enormous bandwidth, and succeeding generations of fiber get better and better. At this writing the highest-capacity fiber for commercial use has a bandwidth of 3.4 Gbps (gigabits per second), and most operate at 565 Mbps.

- This bandwidth is in a very small package, making it especially attractive in areas where existing conduit is becoming overcrowded.

- As the industry learns how to make ever more pure strands of fiber, fewer repeaters are needed to maintain the strength and reliability of the signal.

- Since fiber systems use light rather than electricity, they are not subject to the electrical interference that plagues other systems.

- The quality of the transmission in a fiber system is extremely high.

We hear that cable companies and the telephone industry are both moving rapidly to install fiber in their own plants. Will we have fiber to the home, thus making possible services undreamed of today? Maybe, but not soon. Here's why:

- Although the cost of fiber is going down rapidly, and soon it may be cheaper to install fiber than copper, there is a huge standing investment in twisted copper phone lines and coaxial cable TV lines. Furthermore, not all the potential of those existing systems has been tapped.

- Optical fiber systems transmit pulses of light, which must be converted to electronic signals before they can be used by your home television set or telephone. While fiber itself is becoming cheaper, there is a substantial cost in making the conversion from optical signals to electronic signals. At present it makes sense to make that conversion not in each home, but in the neighborhood (often referred to as "fiber to the curb".)

While fiber may not reach most homes for several years, it is increasingly common in institutions like hospitals, universities, and office complexes, because of its capacity, high quality, resistance to electrical interference, physical size, and decreasing cost.

It is now being used extensively in systems that handle huge quantities of phone, video, and data traffic, such as the trunk lines that carry great streams of information from city to city. Its capacity, quality, reliability, and decreasing demand for repeaters makes it the choice for transoceanic cable systems.

Its capacity and other characteristics, together with the costs of major installations and a more congenial regulatory environment, have invited partnerships and condominium arrangements in the development of fiber systems. Joint ventures between government and commercial carriers, or between phone companies and cable TV companies (normally arch rivals) are beginning to occur.

As costs come down and the demand for telecommunication goes up throughout our society, fiber is no longer only an urban or trunk-line phenomenon. Fiber systems are beginning to provide links for rural areas as well, and they can offer capabilities that most rural areas (indeed, most mid-sized cities) would have found infeasible only a few years ago.

Switches and Switching -- Making That Connection in the Public Network

No discussion of telecommunication/information technologies is complete without a brief discussion of the role of switches in a network. Understanding this component is particularly important to rural communities which seek to deploy new telemedicine technologies using the public switched telephone network.

Placing a call with the public network not only requires an input device (e.g., a telephone) and a means of transmitting the signal (e.g., twisted copper pair), but it also requires a means of routing the message through the network to its destination. This routing is accomplished with devices termed switches. One remembers perhaps the pictures of switchboard operators manually directing (switching) calls. Today, state-of-the-art digital switches are used by almost all the long-distance carriers. These switches, which are actually specialized computers, can connect more than 300,000 calls per hour. At many local exchange offices, however, electromechanical or electronic analog switches, earlier "generations" of switches, are still used.[3]

Because the public network contains several generations of equipment, problems can occur when compressed video signals need to be transmitted, as in telemedicine consultations. That is, transmitting the signals requires not only a high capacity channel (e.g., T1), but it also requires a digital switch to handle the transmission at the local telephone exchange. Therefore, when an institution or community is considering technology deployment, it should recognize that their carrier may have to install a new switch, as well as a new telecommunications line. This may have significant cost implications for the carrier.

Deciding on the Transmission System

Institutional Arrangements. When deciding on distance learning or telemedicine technology, institutions must consider not only the type of technology to purchase, but also how they will obtain transmission services. The choice of technology may actually be less important than the institutional arrangements used to obtain the services. Five common arrangements to explore are[4]:

- Dedicated networks - The institution installs, owns, and operates a specialized private network (this arrangement is common in education).

- Shared government networks - The institution shares capacity with a "private" state or local government network. Some states, however, prohibit a non-governmental entity, such as a private hospital, from using their network.

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[3] Many independent rural telephone companies have been able to "leap-frog" to the new digital technology; i.e., they have gone directly from mechanical switches to digital switches. Many of their Bell counterparts are operating with electronic analog switches -- switches more advanced than the electromechanical, but not as advanced as the digital.

[4] This section is adapted from Parker and Hudson (1992, Chapter 3.) For examples in education see Parker and Hudson (1992); for examples in health care see Schmidt and Smith (in press).

- Leased capacity from telephone carriers - The institution leases network capacity from the telephone carrier. Leasing network capacity is common for video and data services. Leasing may be the only way some telephone carriers offer access to fiber optic facilities.

- Leased capacity from specialized carriers - The institution leases transmission capacity from a specialized carrier (e.g., a satellite corporation, a private commercial microwave or fiber network) for a monthly charge.

- On-demand, "dial-up" networks - Under this arrangement, the institution is able to "dial-up" two or more circuits (e.g., 56 Kbps data circuits) as needed from a telephone carrier. This avoids institutions having to lease an entire line, when only occasional access is needed. Dial-up demand is often used with compressed video technology.

Cost Issues--The "last mile" barrier. Institutions in rural areas frequently face an issue termed the "last mile"[5] barrier. When rural institutions (e.g., hospitals) have begun to deploy these new technologies, some have discovered that the public network telephone lines to their facilities do not have sufficient bandwidth to carry the signals they need to send or receive. Thus, new line must be laid and the costs of its installation covered. Moreover, and as important, a new tariff (or rate) for the new line and service must be developed[6].

This new tariff may be extremely high. General telephone costs are low because the costs are spread over a large number of people. However, when a new line is provided and one facility is the major or sole user of the new high-capacity line, that facility may have to absorb the full costs of transmission services. For example, in the MEDNET project described in the next section, two hospitals to which land-based T1 lines were extended had to lease the lines around the clock, even though they used them only a small percentage of the time. The fixed monthly line charges for the T1 lines averaged $6,050 which, over a 12 month period, almost equaled the one-time equipment start-up costs at each hospital of $80,000.

A Note About Relative Costs. Among high-capacity systems -- microwave, coaxial cable, satellites, and optical fiber -- there are inevitable questions about relative cost. The core fact is that there are no enduring rules of thumb in these decisions: fiber is not always less expensive than satellite, or vice-versa; installing a microwave system is a good solution in certain circumstances, but it may not be cost-effective if a fiber link with available capacity already exists. One must begin by comparing the requirements of the program with the characteristics of the available transmission systems.

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[5] The "last mile" is a term used in describing the laying of fiber optic cable. It to used to connote the distance from the major backbone of the carrier to the peripheral site. In actuality, the "last mile" may be a mile or, in some cases such as west Texas, it may be hundreds of miles.

[6] Local exchange carriers must file with the public utility commission for each different rate or tariff they offer to different customer groups (.e.g, business, residential, or university) and for different services (e.g., voice, data, video).

To an increasing extent, the telecommunication industries face less regulation and costs are market-driven. Systems with excess capacity, or systems facing increased competition, may be prepared to offer incentives.

In review, key questions to be asked when making decisions concerning transmission systems, are:

About the program:

- How many sites are involved?
- Where are they?
- What is to be transmitted between/among them?
- How often and over what period?

About the transmission systems:

- What systems exist or are planned (by the local carrier, by the government, by other institutions)?
- To what extent will they meet the requirements of this program and other potential programs?
- What are their relative costs?
- Must tariffs be negotiated?
- Is a new system, built with this program as a sole major user, a realistic option? What would it cost?

Individual situations invite different solutions. Consider two systems, both of which focus on two-way interactive video: When the State of Oregon decided to proceed with its ED-NET system, it contracted with GTE for satellite service. The State of North Dakota, however, chose an optical fiber system which is also linked to a satellite-based rural hospital network. Both states believe they made the best, most cost-effective choice. Both may be right.

THE TECHNOLOGIES APPLIED TO RURAL HEALTH CARE[7]

This section will examine programs in which telecommunication technology is applied to rural health care. It is by no means a compendium of such projects, but rather a series of working illustrations intended to demonstrate situations in which these technologies have been applied effectively.

It should be emphasized that there is no cookie-cutter approach for applying technologies to problems. There are variables of cost, feasibility of technologies in given situations, information to be sent and to whom, etc. The important thing is to get the job done well, and often there is more than one way to do that. That is one of the lessons in the material below.

Projects Emphasizing Telephone-related Technologies: Phone, Fax, Slow Scan Video, Audiographics

Overcoming the Isolation of Rural Clinicians: The Maine Rural Health Center Clinician Support Network

Problem Addressed: Provide to rural areas a strong physician support system, such as those cultivated by medical schools and enjoyed by those in urban areas.

Technology Applied: Fax, speakerphone.

Program Summary: Maine, a largely rural state with mountainous terrain and harsh winters, has 28 community health centers serving more than 140 remote communities. The ability to maintain quality health care is diminished by the difficulty of persuading primary care clinicians to maintain practices in isolated areas, and health centers are hard pressed to overcome that isolation.

The Maine Rural Health Center Clinicians Support Network was created in October 1991 by the Maine Ambulatory Care Coalition (the state's primary care association), in association with the 28 member centers, the Maine-Dartmouth Family Practice Residency, and the Eastern Maine Medical Center Family Practice Residency. It was funded by a grant under the Rural Health Outreach Program of the federal Office of Rural Health Policy.

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[7] Contact names for the following projects are provided in the CONTACTS FOR FURTHER INFORMATION section at the end of the document.

Key activities of the network include providing consultations among the 70 clinicians, and providing programs of continuing education (both formal credit courses and informal symposiums by teleconference). The telephone teleconferences have proven to be an effective vehicle for linking together the clinicians (whether they are at the hospital or the health centers), residency programs, and the presenters. Clinicians have found teleconferencing to be preferable to video-conferencing because it enables them to participate no matter where they are.

The fax system is used to support the consultation function by transmitting such diagnostic material as hospital EKGs. (For more applications of fax technology, see also the next entry, "More on Fax: Improving Medical Communication.")

Computer modems and Grateful Med Software (see the later entry) are now being provided to all the centers, along with training in their use. This will provide the clinicians at the health centers with another link to essential outside resources.

More on Fax: Improving Medical Communication in Hawaii

Problem Addressed: Improving medical communication between and within hospitals; making it possible for small hospitals to share resources of larger hospitals.

Technology Applied: Fax.

Program Summary: Hospital fax networks have been initiated in several areas, typically for administrative purposes. Analysis of a network established among hospital emergency departments in Hawaii in the 1980s showed that it had great promise for a wide range of applications, including:

Between Health Care Institutions
- Patient transfers
- Telephone patient consultation
- Instant medical records transfer
- Instant ECG interpretation
- Distribution of information from a central source
- Multicenter research links
- Central data collection and organization
- Instant retrieval of medical literature

Within Health Care Institutions
- Sending inpatient medication orders to pharmacy
- Sending lab and radiology reports to patient floors
- Sending supply requests to central supply

The establishment of fax capability in hospitals' emergency departments was advocated because they often serve as the hub for interhospital communication.

Although some of the above fax applications are being assumed by computer applications, fax technology continues to play an important role because of its simplicity and because it can use existing phone lines. Since the above study took place, new applications include using it to obtain signed medical consent in emergencies. One of the investigators in the fax study is now testing the feasibility of teleradiology using a personal computer.

Improving Diagnostic Capability in Rural Communities: Teleradiology and the Nevada Rural Health Project

Problem Addressed: Providing 24-hour access to radiologists for rural hospitals in Nevada (also see additional notes following the Nevada summary below).

Technology Applied: Computer-based image archiving and transmission system.

Program Summary: The Teleradiology Network of the Nevada Rural Hospital Project was launched in March 1990 with hospitals in eight rural communities -- Fallon, Lovelock, Winnemucca, Battle Mountain, Ely, Tonopah, Hawthorne, and Yerington, in conjunction with Medical Video Innovation. Hospitals in an additional three communities -- Elko, Boulder City, and Caliente -- are now part of the project. When the project began, three radiologists provided initial interpretations based on transmitted images, followed by formal written interpretation after receipt of the original films overnight.

In the original system, x-rays and CT films were placed on a camera light box table and viewed by a camera. The camera capture station digitized the film for transmission over the telephone line or for archiving. These digitized images were then transmitted from the rural hospital to a receive computer at the radiologist's station, monitored 24 hours a day. Sending and receiving physicians could view the same image simultaneously.

While this will remain the procedure for x-rays, in 1993 new equipment is being installed for use with CT and ultrasound equipment. In hospitals with CT or ultrasound equipment, a digitizing board is being added to the computer which is connected to the CT or ultrasound equipment. This will eliminate the need to take a picture of the developed film; rather the digitizing board will directly digitize the video signals from the CT or ultrasound equipment and immediately transmit them.

The hospitals within the NRHP have enjoyed a reduction in costs for patients and hospitals by reducing the number of patient transfers to larger, distant hospitals.

These data have been tracked by the NRHP office. Moreover, the community individuals are aware of the teleradiology systems, enhancing their overall view of available medical care. Last, the increased professional.support for physicians has improved the ability of these rural communities to retain their physicians.

Comparable Projects. The Nevada project is not an isolated instance. Projects involving slow-scan or computer-to-computer transmission of diagnostic images have been reported from numerous other rural areas. Among them are western Nebraska, where a teleradiology program was established to spread scarce resources, ease staffing problems, and encourage physician recruiting by rural communities. Others include a program to provide the service of a radiologist to the remote community of Challis, Idaho, by Magic Valley Radiology Associates, P.A. and Sun Valley's Moritz Community Hospital; and that of Northwestern Radiological Associates, which provides services to two small hospitals and three offices in the Seattle area.

It should be noted that there is an ongoing issue of judgment concerning whether the quality of the transmitted image is high enough to warrant its use for final diagnosis. Such systems are commonly reported as comparable to a "wet" reading diagnosis, with final readings made from the original film. Image quality continues to improve, however, and it may be anticipated that an increasing number of radiologists will feel comfortable in using it as time goes on.

Continuing Education in Remote Areas: The Sioux Lookout Project in Northwestern Ontario

Problem Addressed: Provide continuing education to a remote area of northwestern Ontario, including CME programs, medical rounds, nursing rounds, in-service education, health professions student education, and patient education.

Technology Applied: Audio-teleconferencing and slow-scan video.

Program Summary: The Sioux Lookout Zone health care system provides preventive and curative health care to approximately 10,000 native people, over 80 percent of whom live in 27 villages scattered over 100,000 square miles. The zone hospital in Sioux Lookout is staffed with fourteen family physicians plus rotating pediatric and family practice residents from the University of Toronto. Specialty consultants visit the zone, but none live there.

There are fourteen nursing stations staffed by two-to-four nurse practitioners providing primary care under the supervision of the zone hospital. The other villages are served by health aides who are members of the local community and who are visited twice a month by a nurse [illegible] in the region.

Since 1978, the Sioux Lookout Zone Hospital has used teleconferencing to provide ongoing educational opportunities for nursing and medical staff. Nurses based at the nursing stations use teleconferencing to take turns presenting cases. Physicians also use teleconferencing to present cases, aided by consultants (e.g., in cardiology, dermatology, and radiology) in Toronto. Teleconferencing is also used for patient education and for medical and nursing student education.

From 1978 to 1990 the hospital used a slow scan network between four of the nursing stations and the zone hospital for diagnosis and consultations and transmitting x-rays, EKGs, charts, and video images of patients. However, new modes of transportation and communication have replaced the network. Airstrips have been established in all nursing station communities and patients are flown out daily if needed. EKGs are now transmitted using fax technology.

Sioux Lookout found that with a fairly rapid turnover of staff at the nursing stations, meeting the training needs to keep the system operational was difficult.

Audio-Conferencing with Existing Phone Lines: The South Dakota Medical Information Exchange for Training Physicians, Nurses, and Other Health Care Professionals

Problem Addressed: The need to provide education and updated information for diagnostic purposes.

Technology Applied: Audio-conferencing.

Program Summary: The University of South Dakota School of Medicine uses the South Dakota Medical Exchange (SDMIX) for continuing medical education across the entire state. There are over 30 rural teaching sites in addition to the major teaching campuses in Rapid City, Vermillion, Sioux Falls, and Yankton. Educational programs are available to all towns/cities in South Dakota, as well as being available nationally.

The educational programs are mostly clinically oriented and are one hour in length. Program format includes a forty-five minute lecture, supplemented with written materials and slides and/or video, followed by a 15-minute "live" interactive question and answer discussion. Program materials are mailed to each participating site two weeks prior to the date of the program.

More on the Use of Telephone-Related Technologies to Assist Health Care in Remote areas: The Experience of Memorial University of Newfoundland

The Memorial University of Newfoundland is a pioneer in the application of many telecommunication technologies for projects both domestic and international. While recognizing (indeed, helping to demonstrate) the efficacy of advanced video applications and new satellite technology, it was concluded in the late 1970s that many of the most important tasks could be accomplished with audio and related technologies, and that multipoint television would not be economically feasible in the Province of Newfoundland for the foreseeable future.

Accordingly, for more than a decade the university has been developing a province-wide system that is based on telephone conferencing, slow scan television, audiographics, and electroencephalograph and electrocardiograph transmission equipment. For the past year the Telemedicine Centre has been evaluating T1 land-based compressed video technology in health and education applications.

In planning its projects the Telemedicine Centre has applied these guidelines, which would be equally pertinent to many others:

- Use the simplest and least expensive technology that will meet needs.
- Develop a flexible system.
- Involve users (participants, audience, clients) from the beginning of the project.
- Seek the support of administrative personnel in hospitals, clinics, and other agencies.
- Plan carefully for the coordination of the system at all levels.
- Develop a consortium of users within and outside the health field.
- Plan for continuity of service beyond the demonstration project.
- Include evaluation.

Projects Emphasizing Computer Communication

Medical Information to Rural Practitioners: The GaIN Model of the Mercer University School of Medicine, Macon, Georgia

Problem Addressed: Deliver clinical medical library information to medical practitioners, medical students, and hospital personnel in Georgia.

Technology Applied: Microcomputer communication.

Program Summary: Established in 1983, the Georgia Interactive Network for Medical Information (GaIN) provides a 24-hour computer-to-computer link among rural Georgia medical practitioners, Georgia hospitals, and the Mercer University School of Medicine in Macon.

The project responds to the rapid growth -- and decreasing shelf life -- of medical information. Two reports of the Association of American Medical Colleges emphasized the need for increasing the ready availability of information and the parallel requirement for professionals to acquire information retrieval skills.

The mandate of the Mercer University School of Medicine (MUSM) is to help meet Georgia's need for physicians in rural and medically underserved areas of the state. The school thus provides services intended to address problems of professional isolation and lack of information services.

The GaIN system, which links remote microcomputers with a central computer at the university, involves three components:

- physician practice sites and remote clinical teaching facilities;
- hospitals;
- the GaIN Center at MUSM.

Through GaIN, participants may communicate by electronic mail and conferencing, receive advice from colleagues listed in a consultants' register, review educational opportunities on a CME bulletin board, and access biomedical literature through an online catalog and the GaIN MEDLINE. Bulletin boards, which provide current alert services and news services, are tailored to needs of specialized groups. Using electronic mail, physicians may use a librarian's services via their hospital libraries. GaIN can also be used as a gateway to a regional or national computer system, where additional information resides.

Physician Information Online Statewide: the University of Nebraska Medical Center

Problem Addressed: Provide timely information and communication services for health professionals throughout the Midwest.

Technology Applied: Computer Communication.

Program Summary: Synapse Health Resources Online assists in the provision of quality health care -- regardless of location -- by providing timely access to information and communication resources to health professionals. It is a service of the University of Nebraska Medical Center and University Hospital. The health professional, via personal computer, modem and phone line, can access the following:

- Statewide electronic mail (over 6000 addresses),
- medical, nursing, allied health, and pharmacy journal abstract databases,
- online medical library card catalog and online library ordering,
- the Nebraska Medicaid eligibility system,
- the Nebraska professional licensure database,
- multi-specialty bulletin boards,
- continuing education case simulations (credit eligible),
- drug interaction databases and drug information services,
- online patient education materials (in Spanish and English),
- Internet resources (list-serv, mail, FTP),
- decision support and diagnostic aid databases,
- Nebraska Peer-Reviewed Quality Guidelines,
- AMA's practice parameters,
- patient information (pre-reservation, discharge summaries, radiology, and lab results, etc.),
- drug pricing and therapeutic equivalent database,
- the University's bookstore online ordering system, and
- various physician office management activities.

The network consists of over 600 health professionals in over 175 sites in seven states throughout the Midwest.

The University of Nebraska Medical Center (UNMC) also uses satellite and land-line based interactive audio/video for education and continuing education of health professionals in rural regions of the state (see state profiles). UNMC also provides telecardiology services to remote areas.

Physician Information Online Statewide: Oregon Health Sciences University

Problem Addressed: Provide information and communication services for practicing physicians.

Technology Applied: Computer Communication.

Program Summary: A service comparable to that of the University of Nebraska Medical Center is provided by Oregon Health Sciences University (OHSU). The Oregon system is ORHION (Oregon Health Information Online); it is a joint service of OHSU's Biomedical Information Communication Center and US HealthLink, a vendor of medical information services. ORHION is available via personal computer and modem 24 hours a day, seven days a week.

Among the services are:

- OHSU Medline, a five year, 1300 journal subset of the National Library of Medicine's Medline database,
- Access to 320 key medical journals via EMPIRES, Excerpta Medica Physicians Information Retrieval and Education Service,
- Photocopy service and document delivery via fax of mail,
- OHSU library catalog,
- OHSU bookstore service, online ordering and discounted prices,
- Electronic mail,
- Electronic bulletin boards on several topics,
- Comtex Medical News Service,
- Electronic clipping service for topics of the subscriber's choice,
- Clinical information including Medicom Drug Interaction Service, diagnostic support, and patient simulation modules (with CME credit available),
- Full-text reports including the Morbidity and Mortality Weekly Report from CDC Atlanta; the Communicable Disease Summary from the Oregon Health Division's Office of Epidemiology and Health Statistics; and summaries of clinically significant information learned during trials sponsored by NIH.

Extending the Services of the National Library of Medicine: Grateful Med and Loansome Doc

Problem Addressed: Provide access to the databases of the National Library of Medicine (NLM) to individuals in areas without access to a medical library. Provide a means to obtain full-text documents of citations retrieved through Grateful Med.

Technology Applied: Computer communication with the Grateful Med software package.

Program Summary: The MEDLARS family of databases maintained by the National Library of Medicine has long provided support to health professionals. In 1986 NLM introduced Grateful Med, a user-friendly, inexpensive software package that allows an individual, using a personal computer, to search NLM's MEDLARS databases.

In 1992 the Library added the Loansome Doc feature to the Grateful Med software. Loansome Doc enables individuals to order full-text articles from the references they retrieve in their Grateful Med search. The Loansome Doc feature is made available by a medical library in an individual's region with which an individual establishes an agreement for the service.

Virtual Medical Center and Healthnet

Problem Addressed: Isolation of rural health professionals.

Technology Applied: Computer, modem, and telecommunications software.

Program Summary: To decrease the isolation of rural health professionals, two Area Health Education Centers (AHEC), in collaboration with State Offices of Rural Health (SORH), have created and maintain electronic bulletin boards (EBBs) specifically for rural health professionals. The electronic bulletin boards -- "Virtual Medical Center" in Montana and "Healthnet" in Washington state -- serve as electronic information and education resources for rural health professionals. The bulletin boards include message areas where rural health professionals can leave private or public messages. Consulting networks and continuing education courses with x-rays and photographs will be available through the Virtual Medical Center. In-state access to these EBBs is available on a 1-800 number. Out-of-state health professionals can also sign-on to the EBBs, but are responsible for their long distance charges.

Projects Using Broadband Communication Systems or Combinations of Technologies

Providing Specialty Consultation and Continuing Medical Education to Rural Patients and Physicians: The Medical College of Georgia Telemedicine Center

Problem Addressed: Expand the consultative services in all specialties offered at a teaching hospital to include patients in such facilities as rural hospitals, prisons, and community health centers. Provide continuing medical education credit to rural physicians for the time they spend in the interactive consultation with specialists.

Technology Applied: Video, personal computers, fax, medical telemetry via a land-based T1 link.

Program Summary: Through equipment currently based in the emergency room at the Medical College of Georgia (MCG) hospital, the MCG specialist and a physician in a rural hospital can examine a patient together. Technology includes remotely/locally controlled cameras enabling specialists to manipulate camera angles and zoom for detailed patient examination or viewing x-rays on a view box; a microcamera and series of adapters that capture the images from any scope at the remote site; and an electronic stethoscope. Other technologies allow real-time transmission of EKGs with freeze frame annotation and storage of patient images as slides. The system also includes personal computer applications for notes, patient records, and journal references. The network is about to begin a first phase expansion to 25 sites throughout the state.

To date, telemedicine has removed the need for transport of over 80% of patients seen over the network. MCG notes that retention of the patient in the community is improving continuity of care, bringing more timely care, and allowing patients to remain with their families during what is often a stressful time. Comparison of rural to urban daily patient bed costs suggests that retaining the patient at the local facility generally costs the health care system less.

Continuing Education for Rural Hospital Staffs: Oregon Health Sciences University and Northeast Oregon Area Health Education Center

Problem Addressed: Continuing education for health professionals in hospitals in rural northeastern Oregon, provided from Oregon Health Sciences University in Portland.

Technology Applied: Satellite-based one-way video with two-way audio.

Program Summary: The eight hospitals in the Northeast Oregon AHEC (NEOAHEC) have been fitted with receive-only satellite dishes plus audio talk-back in order to receive continuing education programs from Oregon Health Sciences University in Portland. Initial courses were directed to physicians, but courses in nursing and allied health are now also provided.

The program uses the Oregon ED-NET system, which has three networks:

- Network 1 (used in this program) consists of one-way video delivered by satellite, with two-way audio. When fully developed, Network 1 will have about 600 locations throughout the state for receive-only video and two-way audio.
- Network 2 consists of satellite-based interactive compressed video. There are 40 two-way interactive video sites statewide, and a transmission originating from any of them can also be made available via Network 1. Thus, in addition to the "live" interactive sites on Network 2, other sites may receive video and participate by audio.
- Network 3, known as Compass, is a dial-up computer communication network and is terrestrial rather than satellite-based. It provides a variety of information services, including user-friendly access to local, national, and international databases, government and academic libraries, computer conferencing, and electronic mail. Very remote rural sites have local access numbers to the Compass network. It is being used extensively in nursing education and a project is being initiated among nursing executives in the region for sharing details on educational opportunities jointly available among their institutions.

Baccalaureate Programs for Nurses: the Approaches of Hawaii, New Mexico, and Oregon

Problem Addressed: Make it possible for practicing nurses located in rural areas to complete baccalaureate or masters programs in their home communities.

Technology Applied: Video, audio, ancillary technologies. Various approaches are illustrated by the three cases.

Program Summaries. Hawaii, New Mexico, and Oregon are addressing essentially the same problem: how to make baccalaureate or masters' programs in nursing available to practicing nurses in rural areas. All use telecommunication. From the standpoint of the students the approaches are similar, but distinctly different technical systems are employed. The essential lesson is that different systems, chosen as best in their respective situations, can provide similar service.

The three systems are as follows:

The University of New Mexico. One-way video via satellite plus two-way audio by telephone is used to transmit five courses per year to about 30 sites, which are located in rural hospitals or community colleges. Courses are offered live, with live phone connections to the students wherever they may be. Video transmissions are also captured locally on VCRs.

Two clinical courses are not involved in the broadcast schedule. Lower division courses may be taken from community colleges. Completion of the program normally takes about two years of continuous enrollment beyond the lower-division requirements.

The University of Hawaii at Manoa. The University of Hawaii at Manoa offers a Master of Science in Nursing outreach program. The instructional approach is similar to New Mexico's, but the technical system involves a combination of point-to-point microwave and ITFS, all part of the Hawaii Interactive Television System (HITS). The HITS system reaches the islands of Oahu, Kauai, Maui, and Hawaii, with origination possible from the islands of Hawaii (the University of Hawaii at Hilo), Maui (Maui Community College), Kauai (Kauai Community College), and Oahu (the University of Hawaii at Manoa, Kapiolani Community College, Leeward Community College, Honolulu Community College, and the State Department of Education).

Oregon Health Sciences University. In Oregon both the basic nursing baccalaureate curriculum and the RN/BS completion program are offered to selected sites throughout the state. The technology employed is two-way compressed "live" video via Oregon ED-NET's Network 2 and computer conferencing for class assignments via Network 3. (As noted above, ED-NET Network 1 is a one-way video with audio return satellite network; Network 2 is a two-way video, two-way audio network using digital video compression; and Network 3 -- Compass -- is a low-speed computer communications network. Networks 1 and 2 are satellite-based, while Network 3 is terrestrial-based.)

The telecommunication system is seen as integral to the long-term development of nursing programs in Oregon. The state's nursing programs are being merged, with OHSU as the lead institution. Providing the program to local communities via telecommunication is central to the planning process.

Note: Nursing programs require clinical practice. In these programs clinical components are arranged through local hospitals where appropriate supervision is available, or faculty members travel to assure that clinical work is completed satisfactorily.

Training Health Professionals in Rural Areas: Interactive Video in North Dakota

Problem Addressed: Provide people in rural areas an opportunity to receive training in health professions, and respond to the shortage of health professionals in the state.

Technology Applied: Interactive video via an optical fiber network and satellite.

Program Summary: Bachelor of science degree programs in nursing, social work and medical technology are offered from the University of North Dakota, using two-way interactive video and audio.

North Dakota has an optical fiber network linking the state's public colleges and universities and the state capitol. This Interactive Video Network (IVN) is intended as the first step toward making broadband service available throughout the state. Fourteen classrooms equipped with optical fiber links currently comprise the network. The fiber system is now being complemented by (and linked to) a satellite system called MEDSTAR, which has receive-only dishes in 32 rural hospitals.

Statewide Continuing Education for Physicians, Nurses, Other Hospital Staff, and Patients: The Health Communications Network of the Medical University of South Carolina

Problem Addressed: Provide an ongoing program of continuing education to physician, nurses, allied health professionals, administrators, hospital support staff, and patients.

Technology Applied: Video transmitted via microwave; telephone.

Program Summary: The Health Communications Network of the Medical University of South Carolina is a full-color broadcast facility. The Medical University maintains a full-service production studio facility; State teaching hospitals in Greenville, Columbia, and Spartanburg maintain production origination capabilities. The network provides over 120 hours of continuing education programming each month, reaching an audience of 25,000 to 30,000 health care providers and consumers each year. Programming is broadcast to more than 75 on-site classrooms in South Carolina, linking more than 50 hospitals and state agencies.

In addition, the Network's microwave system is used to transmit two-way video/audio interactive undergraduate and graduate courses among the Medical University of South Carolina, the University of South Carolina School of Medicine, Clemson University, Spartanburg Regional Medical Center, Greenville Hospital System, and Richland Memorial Hospital. One-way video, two way audio teleconferencing facilities via satellite are also available.

Improving Rural Health Care in West Texas: Three Successful Telecommunications Demonstration Projects - MEDNET, KARENET and Tech Link

Problem Addressed: Improve rural health care and health professions education in West Texas and alleviate professional isolation.

Technology Applied: T1 compressed interactive video, satellite-delivered video, slow-scan video (static imaging), facsimile, computer network.

Program Summary: The MEDNET pilot program began in 1989 with a major federal grant. Activities initiated under MEDNET are now continuing under Texas Tech's HealthNet organization.

The four elements of the former MEDNET program are:

- Clinical consultations between generalists and specialists facilitated by T1 lines carrying two-way compressed video, audio, graphics, and data. Patients at two rural hospitals, Alpine and Ft. Stockton, can be "seen" at Health Sciences Center facilities in Lubbock, Odessa, or El Paso. In August 1993, the T1 link was extended from the hospital in Alpine to a small rural health clinic in Presidio, Texas on the Mexico-Texas border. With this link, physician assistants (PA) in Presidio can consult with physicians in Alpine. When the link is completed, the Presidio clinic will also be linked to Odessa and Lubbock allowing the PAs to consult with HSC's specialists.
- High-quality static imaging for transmission of X-rays. Other diagnostic material (e.g., text) is transmitted using personal computers.
- Continuing education - including grand rounds, case conferences, seminars, and workshops for physicians, nurses, and other health care professionals. One-way video via satellite, with two-way phone interaction is used to deliver CE at 46 hospitals.

- Fax equipment. Originally installed in 19 sites to facilitate document transfer from the Health Sciences Center libraries, doctors quickly found that they could use the system effectively for fetal monitoring consultations. (This reduces the number of patients who would otherwise be automatically referred to specialized care centers.)

A report on the MEDNET program summarized its benefits as follows:

- Made possible physician-to-physician and physician-to-physician assistant or nurse practitioner consultations without geographic limitations.
- Kept patients in local care settings, increasing patient revenues at the home facility and reducing the expense of patient travel for both the patient and taxpayer.
- Allowed rural health professionals to receive and participate in continuing education programs locally, at greatly reduced expense to the local hospital.
- Decreased professional isolation.
- Increased the availability of diagnostic resources.
- Improved access to current medical literature.
- Helped support and supervise health professions students in rural training sites.
- Increased the confidence of rural patients in their local physicians and hospital and enhanced the rural hospital and community's ability to attract and keep primary care physicians and staff.

The Kellogg Affiliated Remote Environments Network (KARENET), Texas Tech's first health network, was funded under a grant from the W.K. Kellogg Foundation. KARENET used computers, with staff-developed software programs, to link sites in El Paso, Lubbock, and rural Morton. The computers provided access to a variety of services, including patient management protocols, on-line conferencing for medical consultations, access to an automated health care record system, continuing health professions education programs, and patient education programs targeted to community health needs.

Tech Link, a video conferencing network operating on a T1 line, was initiated in 1987 to connect the Texas Tech Health Science Center in Lubbock with its three rural academic health centers in El Paso, Amarillo, and Odessa. Tech Link is used to provide lectures to students at the four medical school campuses and is also used for administrative purposes (e.g., faculty and staff meetings).

After the potential of these projects was demonstrated, Texas Tech created HealthNet in 1992. HealthNet integrates these three demonstration projects and other rural health outreach projects into a comprehensive effort addressing West Texas' rural health needs.

Oregon's RODEO Net: Meeting the Needs of Mental Health Service Providers in Rural Areas

Problem Addressed: Advance the purpose of the Eastern Oregon Human Services Consortium to provide for the cooperative management of mental health programs, and to develop and operate specialized mental health services in as cost-effective a manner as possible.

Technology Applied: The three networks of Oregon ED-NET: one-way video with two-way audio; two-way interactive video and audio; and a dial-up computer network.

Program Summary: The goals of the RODEO Net Project are as follows:

- Improve patient care through increased access to and communication with necessary resources.
- Develop a well-trained and confident mental health workforce in remote communities by enriching ongoing training and staff development opportunities using telecommunication technologies.
- Determine if telecommunications is a cost-efficient and effective means of service delivery.
- Encourage policies that reflect the changing nature of service delivery in the use of telecommunications, particularly in the area of funding public mental health services.

Using interactive video telecommunications, RODEO Net provides services such as 24-hour crisis response for persons suffering extreme emotional or behavioral turmoil; mental health case consultation with physicians and other professionals; pre-admission services and pre-discharge interviews; and pre-commitment hearings.

The training function of RODEO Net includes one staff development certificate program for professionals and paraprofessionals working with children who have severe emotional disturbances; two staff development certificate programs in the planning stages; individual training sessions as requested by regional steering committees or sessions that take advantage of guest speakers or training programs at other sites; and a post-masters' program in psychiatric/mental health nursing from Oregon Health Sciences University for a small group of nurses at the Eastern Oregon Psychiatric Center.

Reducing the Isolation of Rural Practitioners: Mountaineer Doctor Television (MDTV)

Problem Addressed: Demonstrate the value of telemedicine consultations for reducing isolation of practitioners and enhancing access to specialist care in rural areas.

Technology Applied: Two-way compressed interactive video and audio via dedicated T1 terrestrial phone lines.

Program Summary: Based at West Virginia University Health Sciences Center, the Mountaineer Doctor Television project will link the Health Sciences Center (HCS) to four hospitals, providing for 24-hour video consultations and emergency assistance between rural physicians and the specialists at HSC.

The program will also include interactive continuing education for health professionals, as well as training for students of the health professions and residents who are doing rural clinicals. In addition, the system will be used for weekly grand rounds and to provide the nursing program to students in a rural community. The MDTV program began with its first continuing education program and its first telemedicine consultation to one hospital site in July 1993. Three additional hospitals will be added within a year.

Exploring the Potentials of the Internet for Community Hospitals: Pilot Connections in the Pacific Northwest

Problem Addressed: Explore the efficacy of providing health professionals in community hospitals, including rural community hospitals, with access to networking and health information resources via the Internet.

Technology Applied: Advanced computer communication.

Program Summary: Perhaps this project should be categorized with other projects emphasizing computer communication, but its scope suggests a home with these programs which use combinations of technology, including broadband systems. Based at the University of Washington, the project is coordinated by staff of the Regional Medical Library and the hospital librarians at the project sites. The project is assisted by NorthWestNet, the regional computing and communications network which manages the regional sub-unit of the Internet. The Pilot Connections program is conducted through the university's Regional Medical Library contract program with the National Library of Medicine.

The program's overall goal is to explore optimal technical, financial, and user models for extending network access to community hospitals. The program's objectives are:

- To assess the costs, benefits, and relative suitability to community hospitals associated with dedicated, multi-user network access vs. dial-up, single-user access.
- To observe the extent to which networked information resources and services -- made accessible by way of network connections -- are introduced to and used by hospital staff, and note the factors that seem to affect this in the various settings.

Seven community hospitals in five states are involved in the project. Three of the hospitals are connected to the Internet using 56 Kbps dedicated line connections for simultaneous multi-user access; four hospitals are connected using dial-up access.

Individuals at the seven sites are using their new access for:

- e-mail and electronic discussion groups,
- participating in continuing education programs offered online,
- communicating with a defined group of colleagues for such purposes as the business of a professional organization,
- checking the FDA Bulletin Board for information on the status of drugs,
- collaborating on reports and professional writings,
- quickly and inexpensively searching the databases and databanks of the National Library of Medicine,
- quickly obtaining the full-text of journal articles or book chapters with high resolution,
- transmitting datasets, such as abnormal chromosome laboratory results which are lengthy, complex, and difficult to transcribe accurately,
- checking late-breaking weather reports for emergency airlift pilots,
- searching the catalogs of libraries all over the world.

Testing of document image transfer hardware and software (Ariel) began in March of 1993. The equipment and software program allow the librarians to scan pages of books or journals and transmit these as files over the Internet. This is used for interlibrary loans in lieu of photocopying and mailing, or faxing, and is cheaper, faster, and provides a document of a higher quality. The participating community hospitals are:

Alaska Native Medical Center, Anchorage, Alaska
Kootenai Medical Center, Coeur d'Alene, Idaho
Kalispell Regional Medical Center, Kalispell, Montana
Shodair Children's Hospital, Helena, Montana
Merle West Medical Center, Klamath Falls, Oregon
Providence Hospital, Everett, Washington
St. Peter Hospital, Olympia, Washington

Statewide TeleHealth Projects

Many telemedicine initiatives have been singular projects based out of single entities, eg., universities - (MEDNET at Texas Tech University, MDTV at the University of West Virginia, the telemedicine project at the Medical College of Georgia). In some states however, the movement in telecommunications has been at the state level -- for health care, education, health professions education, or rural development.

GEORGIA: Georgia's "Distance Learning and Telemedicine Act," passed in 1992, allocates $50 million from telephone company over-earnings to finance state telecommunications projects in medicine and education. Specifically, the act directs the state Department of Administrative Services (DOAS) to develop, implement, administer, and manage a consolidated, integrated, statewide, shared-use distance learning, and telemedicine network. As the first step in doing so, the needs of the educational and medical communities are being defined. Based on this information, DOAS will make decisions about transmission technology alternatives. A Distance Learning and Telemedicine Board has been established to oversee and administer the fund.

IOWA: Three years ago Iowa legislators passed an act to create a statewide fiber optic network[8], the Iowa Communications Network (ICN). ICN was initially constructed to provide educational opportunities for Iowans from K-12 through the university level and also to provide access for state government and libraries. A large portion of the costs of network construction has been covered by issuing bonds. The educational use of the network is subsidized, providing particularly inexpensive educational rates.

Recently, it has been suggested that ICN be opened to health care providers as a means to enhance health care services in rural Iowa. A consortium of Iowa hospitals and universities has been pursuing a cooperative venture with the ICN to develop a statewide medical information network -- the "Iowa Medical Information Network." In July of 1993, the consortium demonstrated specific health applications on the network.

KANSAS: In Kansas, a state-wide telemedicine planning initiative was jump-started with a grant from the Kansas Health Foundation. The Foundation jointly funded the Kansas Hospital Association and the Kansas Department of Health and Environment to study possible applications of telemedicine in Kansas. The goal of the initiative is to develop materials to help educate individuals about telemedicine and to provide a structured approach for evaluating and implementing telemedicine applications in Kansas.

A public/private policy group comprised of the range of players -- government representatives, health care providers, insurers, educators, and interested others -- was established to guide the project. A four-volume report has been developed for communities to use to evaluate their telemedicine applications. This includes an overview of current telemedicine applications, an overview of policy issues, a community planning guide for telemedicine, and a source book of references.

NEBRASKA: In the late 1980's, the Nebraska Educational Telecommunications Commission recommended that its 25-year-old nine-transmitter microwave system, used to deliver educational television, be updated. Agreeing, the state legislature funded NEB*SAT -- a satellite and fiber optic system. The system's backbone is a transponder on the Spacenet III satellite. The system is capable of simultaneous broadcasting on three networks: a broadcast-quality TV channel for ETV and public radio, a second broadcast-quality channel for distance learning, and narrow-band channels for compressed video (16 one-way or 8 two-way channels).

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[8] The ICN is a synchronous optical network (SONET) with transmission speeds up to 2.4 gigabits per second. The 2.4Gbps network of Phase I will link Iowa's three regent universities and 15 community colleges in regional centers, the state capital, Iowa Public Television, and the Iowa Network Control Center at the Iowa National Guard Armory in Camp Dodge. The 84 links of Phase II, which will extend the links from the regional centers to the remaining counties and support 565Mbps transmission speeds, will tie in primary high schools and community college branch campuses. Phase III links will tie in most high schools on leased connections.

The system is available for use by all University of Nebraska campuses, state and private colleges, technical and community colleges, the state Department of Education and public radio. It is currently used to deliver nursing, medical technology, and other health science education classes. It is also used for academic administrative meetings and for continuing education programs.

NORTH DAKOTA: In North Dakota, telehealth telecommunication efforts initially focused on health professions training needs for individuals in rural communities. Under a grant from the Department of Agriculture, the University of North Dakota and North Dakota State University collaborated to establish the "Rural Health Distance Education Project" in 1989. The project offers entire health professions degree programs in 14 classrooms throughout the state using a two-way interactive video system - IVN (see project description, page 35).

OKLAHOMA: The Oklahoma Medical Information Network (OMIN) is a three-year pilot project funded by a restitution fund from the U.S. Department of Energy. (The fund was established by DOE to redress gas and oil overcharges between 1973 and 1981.) Under phase one, a teleradiology system is being established to link six rural medically-underserved sites with the University of Oklahoma Health Sciences Center. Under phase two, an information system for data retrieval via computer will be implemented, and under phase three, interactive video teleconsultations will be established.

PENNSYLVANIA: Pennsylvania Governor Robert Case announced plans in May of 1993 for the Pennsylvania Rural Health Communications Network (HealthNet). This network will be instituted in three prototype phases, the first to begin in October 1993. The network will connect understaffed and underequipped rural hospitals and community health centers with larger, better-equipped hospitals via two-way video/audio connections, teleradiology, and computer-to-computer conferencing.

SOUTH DAKOTA: South Dakota's "Rural Development Telecommunications Network" (RDTN) grew out of a telecommunications task force formed in 1990 by the late Governor Mickelson. The network was developed with funding from a variety of sources, including a Federal Energy Conservation grant and a Future Funds grant secured by the Governor's Office of Economic Development. The network came on-line in December of 1992, first hooking-up six educational institutions in the state. Education has priority for scheduling and the recent hook-up of three hospitals -- one rural facility and two urban tertiary care centers -- is for educational and administrative purposes. Discussions are being held to explore the use of the network for medical video consultations.

TELEHEALTH AND USER SUPPORT

Those involved in telemedicine and its close relation, distance learning, recognize that it is not enough to install the equipment, turn it on, and find people who want to use it. Support is required at several points. The purpose of this section is to point out common areas in which support is essential if programs are to succeed.

Is the System Ready? The world has all too many disgruntled souls who have tried technology and found it wanting. The dreaded line, heard often when we gather in professional conferences, is, "At our place we tried [fill in the technology] and it didn't work." Most commonly behind this complaint is either of two situations:

- For any of several possible reasons the system became operational before it was fully installed and thoroughly tested. Its start-up glitches were revealed, its backers were embarrassed, and potential users, understandably enough, avoided it. The technology was blamed for the failure.

- The early users of the system were not properly trained and supported. They floundered, the system seemed clumsy and reaction was poor. It was concluded that the technology didn't work.

Training of Users. At the very least it is necessary to acquaint users with the technology and the situations in which it will be used. The purpose of this training is not to burden them with technical detail, but to make users sufficiently familiar with the equipment that they can use it comfortably and recognize the opportunities and constraints that are built in.

For those taking part in a telephone conference, the problem is minimal: recognize the need for some protocol in managing the session, so that all can participate equitably so that votes can be taken or consensus recognized, etc.

For those responsible for presenting a multi-site two-way video course or consultation, the need for training is greater. It's not complicated, but it takes practice and attention.

Example: For those who wish to use the technology to provide medical consultation, thought must be given during the design phase to such issues as the location of the equipment in the health facility, the portability of equipment, operation and control of the equipment, and the elements of camera-patient-clinician interaction. Then, with adequate training and support, those who use the system can concentrate on the business of the moment, not distracted by the machinery of the system.

Training of Students. Health professions training programs that are preparing students for rural practice also share a responsibility for training students in the use of some of these technologies. At a minimum, students should be trained in the use of computers to search medical/health information databases and exposed to other electronic information and networking resources.

Ongoing Technical Support. Those in the health professions are well aware of the need for regular, competent maintenance and upgrading of hospital equipment. There is a similar requirement for telecommunication systems. While the equipment in the systems described above is relatively stable and hardy, regular maintenance is essential.

Furthermore, the technology is developing so rapidly that an important part of technical support consists of tracking change, recommending equipment updates when there are significant advances or when it becomes more economical to replace equipment than to maintain it.

Technical support at the operational level -- operating or monitoring equipment when a consultation or course session is in progress -- is also important in many systems and can be critical to the success of the program.

Technical support is an area which too often receives little attention, inevitably to the detriment of the program's success.

REGULATORY, LEGAL, AND QUALITY ASSURANCE ISSUES

This section provides a basic overview of some of the regulatory, legal, and quality assurance issues confronted by those implementing telecommunication systems. For more detailed discussions about these issues, please refer to the resource section of this publication.

Frequently, individuals in education and health care who are considering investing in telecommunications systems focus first on the technology and its capabilities. However, the regulations guiding telecommunications infrastructure and services will have a significant effect on how distance education and health care services will be made available to rural areas. A basic understanding of the players and issues is therefore important. As Ellen Wagner[9] has pointed out, it is critical for users of these systems to be aware of some of the complexity in order to insure their best interests are being served and that they are paying the right price for the services needed to serve the public. Moreover, such an understanding is critical if those in health care and education are to influence telecommunications policy decisions.

The education community has been involved to a greater degree and for a longer period of time in utilizing telecommunication technologies than has the health care community. Although in the early 1970s there were a few small telecommunication projects serving health care needs in rural areas, there was little activity in the area during most of the 1980s. It has only been within the last few years that a critical mass of health professionals and facilities has begun using these technologies. Thus, it is only recently that the need has arisen in the health care community to examine, as the educational community has done for the past decade, the legal, regulatory, reimbursement, and quality issues surrounding telecommunications utilization.

The Regulatory Players

Telecommunications regulatory authority and policy making are shared by a range of public sector players including: the *Federal Communications Commission (FCC)*, an independent federal agency responsible for coordinating the use of the airwaves and with oversight over broadcasting, cable, and telephone industries; the *National Telecommunications and Information Administration (NTIA)*, Department of Commerce, the executive agency responsible for coordinating executive branch telecommunications policy; *federal courts* which administer decisions affecting the industry (e.g., the Modification of Final Judgment that resulted in the breakup of the Bell System); *state public utility commissions*, responsible for regulating intrastate and local telephone service; and *state and local authorities*, responsible for regulating local cable franchises (U.S. Congress, OTA, 1989: 150).

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[9]. Some of the information presented here was developed by Ellen D. Wagner while a visiting faculty member with the Western Cooperative for Educational Telecommunications. A more thorough examination of the regulatory environment can be found in Dr. Wagner's chapter, "Regulatory Issues in Distance Education," in B. Willis (Ed.) *Distance Education: Strategies and Tools*. Englewood Cliffs, NJ: Educational Technology Publications. It is scheduled to be published in January 1994.

Higher Education

Legal concerns surrounding tele-education involve a range of issues, including the implications of interstate telecommunications instruction and possible conflicts between states' rights to control education and the constitutional prohibition against their regulating interstate commerce. They also include issues relating to potential first amendment constraints, equal protection, restraint of trade, civil rights, and the determination of "physical presence" of an institution in a state (Chaloux, 1985 as noted in Reilly and Gulliver, 1992).

One of the first attempts to grapple with these issues in higher education was the Project ALLTEL (the Project on Assessing Long Distance Learning via Telecommunications - 1982-1984). Co-sponsored by the Council on Postsecondary Accreditation (COPA) and the State Higher Education Executive Officers Organization (SHEEO), Project ALLTEL specifically addressed issues of state authorization and voluntary accreditation relating to higher education delivered using telecommunications across state lines. The project also helped frame the legal, regulatory, and quality assurance context for telemediated education. As a result of Project ALLTEL, COPA and SHEEO issued a policy statement on "Accreditation and Authorization of Distance Learning Through Telecommunications in 1984."

A later effort in education, the 1990 invitational symposium on "Emerging Critical Issues in Distance Higher Education," also focused on quality assurance in distance education, as well as regulatory and accreditation issues. The symposium, convened by the Regent's College Institute for Distance Learning, the Annenberg/CPB Project, and the American Council on Education, noted the need to establish a research agenda that would inform policy development in distance learning.

The latest effort in this arena is a 1993 project that includes most of the players in these earlier efforts. The Western Interstate Commission for Higher Education's (WICHE) Western Cooperative for Educational Telecommunication is working with the educational policy makers of 15 western states to establish mutually compatible standards for telecommunicated interstate degree programs. A similar effort is under way in the Southeast headed by a regional higher education accrediting agency.

Although the higher education community has grappled with, and addressed, quality issues since the 1980s, it faced a significant challenge even as late as 1992. In 1992 legislation was introduced in the Congress that would have declared instruction delivered via telecommunications to be correspondence study. The rationale was that instruction provided via telecommunications technology was not of the same quality as that offered in a face-to-face situation. In higher education, such a decision would have dramatically affected students' eligibility for financial aid as well as the funding of telecommunication projects. The educational telecommunications community mobilized to inform key congressional staff about the scope of current activities in this arena and the potential impact of such legislation on students. The result was legislation that defined a broad scope of telecommunicated classes that were separated from the category of "correspondence courses."

Health Care

Many of the issues addressed by the educational community have counterparts in the health care arena, with specific health care twists. For example, the health care community is now beginning to address the following issues:

- Quality of health care delivered by telecommunications,
- Reimbursement of care delivered by telecommunications -- in particular video-to-video consultations[10],
- Licensure of health professionals who deliver telemediated care across state lines,
- Privacy issues in terms of patient information in clinical networks and clinical consultations, and
- Protocol development for participation in telemedical consultations.

Just as those involved in tele-education grappled with issues relating to the quality of telemediated coursework, the health care community is now confronting issues relating to the quality of telemediated consultations. And, as in education, decisions based on concerns about quality have dollar ramifications. Many public and private health care insurers are not yet willing to reimburse for telemediated care (i.e., remote diagnostics and consultations) because of concerns about quality, efficacy, safety, and costs. The Health Care Financing Administration (HCFA), which administers the Medicare and Medicaid programs, has given its regional offices authority to determine whether they will pay for telemedicine services. However, many of them are waiting for a stronger mandate from HCFA headquarters before they reimburse for services. Many private insurers who have historically followed HCFA's lead in reimbursement policy are likewise waiting.

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[10] Telepathology and teleradiology, which involve the transmission of computerized data and images, are already covered by many insurers.

Rural health care facilities and professionals are also confronting regulatory and quality assurance/liability issues that relate to their ability to access health information services for health care delivery. For example, the Joint Committee on Accreditation of Healthcare Organizations (JCAHO) has revised its standards for 1994 to require hospitals to provide access to authoritative and up-to-date print and non-print information resources in a timely and efficient manner. For many small rural hospitals unable to maintain these sources in a print format, electronic access to information resources may be the only cost effective means by which they will be able to meet such standards. Similarly, rural clinicians' access to the latest clinical information also is increasingly important in terms of quality of care and related professional liability issues. Physicians are being held responsible for searching the current literature to seek, find, and apply the latest medical information when treating patients (Montana Task Force for Biomedical Information, 1993).

Several activities are now underway to address health care telecommunications issues. The federal Office of Rural Health Policy is convening an invitational workshop in November 1993 to identify and address the major barriers, including regulatory and policy barriers, inhibiting the diffusion of telemedicine to rural communities. In mid-1993, the Health Care Financing Administration contracted for a survey of the current uses of telecommunications technologies in expanding access to health care and an analysis of these uses as they relate to the development of Medicare coverage policy.

The Rural Electrification Administration is funding a major demonstration program to develop and expand the rural applications of telecommunications technology for distance learning and health care. The National Library of Medicine funds an outreach initiative to provide health professionals in rural areas with access to information services. More recently, as part of the High Performance Computing and Communications (HPCC) Initiative, NLM has solicited proposals to advance the medical applications of advanced computing and digital communications. Finally, telemedicine issues are being addressed by the American Telemedicine Association. ATA was founded in 1993 to promote professional, ethical, and equitable improvement in health care delivery through telecommunications technology.

Cost of Access

Another critical problem for those involved in providing education and health care in rural areas using telecommunication technologies is that of cost. Not only do rural areas need access to technologies that are comparable to those in urban areas, such access must be comparably affordable. The small populations and large distances of the rural regions are generally incompatible with the economies of scale that characterize many aspects of telecommunications. As a result, market forces rarely work to benefit rural areas. As the Congressional Office of Technology Assessment has pointed out, regulatory mandates and incentives are frequently necessary.

To understand some of the regulatory issues surrounding costs, the concept of tariffs must be understood. The United States Public Switched Telephone Network (PSTN) evolved as a monopoly. Consequently, telephone service providers do not operate the way most businesses do in a free-market system. The rates they can charge are controlled by a state public utility (or service) commission.[11] Thus, a carrier cannot simply decide what price to put on a service. Rather, it must file a price schedule, called a tariff or rate, with its regulatory commission. Once the regulatory commission approves the rate, the services are offered at those standard prices to any user.

Most tariffs in use today were designed primarily for voice and data transmission and may be inappropriate for the capacity required for video transmission (Koch, 1991). Thus, pricing policy -- especially for video services -- is still evolving as telephone companies gain more experience with video transmissions and processing technologies. Because no standardized price structure or tariffs exist for multi-channel video service, telephone companies are pricing services on a case-by-case basis.

Institutions considering installing new systems should investigate the pricing structure available from their carrier. They should be prepared to negotiate rates, which may entail waiting several months for the regulatory approval of a new rate. And they should be aware that because state public utilities set the tariffs, the rates for services will vary from state to state, as well as within states depending on the circumstances in the community.

As noted earlier, the Texas Tech MEDNET project had to lease a T1 line around the clock, even though they used it only a small amount of that time. This was because they were not successful in negotiating for on-demand access.

Players in education and health care are now recognizing, and beginning to address, needed regulatory reforms at both the federal and state level. Such reform includes providing incentives for telecommunication carriers to develop alternate pricing for educational and health care applications. For example, in a 1991 Congressional hearing chaired by New Mexico Senator Bingaman, several witnesses called for national policy recommendations dealing with specific regulatory reforms to reduce the cost of common carrier telecommunications charges for educational purposes.

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[11] The tariffs and price structures for communication facilities set forth by PUCs are intended to allow telephone companies a fair rate of return on their capital investments.

Several states have already instituted regulatory reform. In 1989, the Kansas Corporation Commission began to allow regulated telephone carriers, on a case-by-case basis, to implement reduced "Economic Development Rates" for services provided to certain types of entities, including educational organizations. Tennessee's Public Service Commission (PSC) developed two special educational tariffs. The first rate is for basic phone line service to elementary and secondary schools. The discounted rate is specifically for lines used for computer connections to information databases in classrooms and teachers' workrooms and for lines used by teachers to place outgoing calls to parents. This PSC also established a second educational tariff for high capacity private lines to educational institutions (i.e., T1 lines capable of transmitting interactive video signals). This second educational tariff is 50% less than the rates paid by other private line customers.

Copyright Issues: While these developments indicate enhanced access to telecommunications resources for educational groups (and the potential for similar access for rural health care), there are still many issues that need to be addressed. No one has solved the problems that arise with the United States' copyright system when intellectual material is "published" electronically and can be available on a network that is accessible to anyone with a computer, modem, and telephone line. There are some experimental projects, mostly in the library community, but no single solution exists (and may never). The ability to address this issue will affect how quickly such applications are available to the general public. This has particular significance for health professionals in rural areas where access to extensive print-based collections are limited.

Interoperability/System Compatibility: The interoperability (or compatibility) of different communication systems is another issue that must be addressed. Regulatory agencies, responsible for establishing rates, also set standards and protocols necessary to insure compatibility among communications systems. This allows different systems to communicate with each other, important in both education and health care. This is particularly important for rural communities. For example, Nebraska is served by 42 different telephone companies with different operating systems and technological bases. In order to be able to provide telemedicine services over these lines, interoperability must be assured.

Evaluation and Research

The effectiveness of the use of telecommunication technologies for secondary and post-secondary education is fairly well documented. Students studying at a distance tend to score about the same on tests as their counterparts in the face-to-face sessions of the same class. In many cases, students studying at a distance perform better than students in traditional classes probably for two reasons: (1) the off-site students are typically older, more motivated students than those studying on the campus, and (2) classes taught using technology frequently are designed more systematically to create a successful learning experience for the students.

For example, all the materials for the course are developed for specific learning goals and can take advantage of a variety of technologies. Those parts of the course content that require a verbal explanation (lecture) can be videotaped for students to view at the appropriate point in the course. This tape can last as long as it needs to and does not have to conform to a specific number of minutes of scheduled classroom time. Discussions can be scheduled on selected topics using computer conferencing or audioconferencing that might include a particular expert in the field. "Papers" can be written and revised and shared with groups of class members using electronic communication. Students can have access to the faculty member on a one-to-one basis through electronic mail, voice mail, or telephone calls.

There is far less evaluative information specifically on the effectiveness of distance learning for health professions education and continuing education. Although educators have been studying media-assisted learning for over 50 years, there are few studies on its utilization in the health professions, particularly with newer technologies.

There is also little evaluative material on the effectiveness of telemedicine as a means of providing care -- both in terms of clinical effectiveness and cost-effectiveness. This is in part because most telemedicine projects are recent endeavors. Moreover, the current emphasis in medicine on outcomes research, including quality, appropriateness, and cost-effectiveness of care, is a fairly new phenomenon. The Medical Treatment Effectiveness Program, the major federal effort to understand and address practice variations, was established in 1989.[12] Efforts in telemedicine to study issues of clinical effectiveness as well as cost-effectiveness are thus hampered by a lack of research and research models in the field overall.

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[12] This research program is managed by the Federal Agency for Health Care Policy and Research, one of the eight agencies of the U.S. Public Health Service, DHHS.

Evaluation and research in health professions distance education and telemedicine are needed if these applications are to be successfully developed and effectively used in rural America. Rural communities need guidance before they invest scarce resources in expensive equipment that may not be adequate or appropriate for their needs. Federal agencies and decisionmakers need additional information to assure that new rural telemedicine projects are appropriate and effective. Reliable information about how well different technologies work for different purposes, the relative costs of those technologies, and the lessons that were learned by the pioneers in this field, could help others avoid the same mistakes and improve on the efforts of others.

CONCLUDING COMMENTS

Rural Networks and Superhighways

The telecommunications infrastructure is undergoing rapid growth and change. Information and telecommunication technologies are being developed and deployed at an ever increasing pace. The regulatory arena is in great flux as it attempts to adjust to the constantly changing environment. In this new information age the danger exists that telecommunications technologies and sources of information may be inequitably distributed, tilting toward overabundance in urban areas and scarcity in rural areas. Rural communities have an opportunity to help shape what they will have available to them. Health professionals knowledgeable about the options can help their rural communities make wise choices.

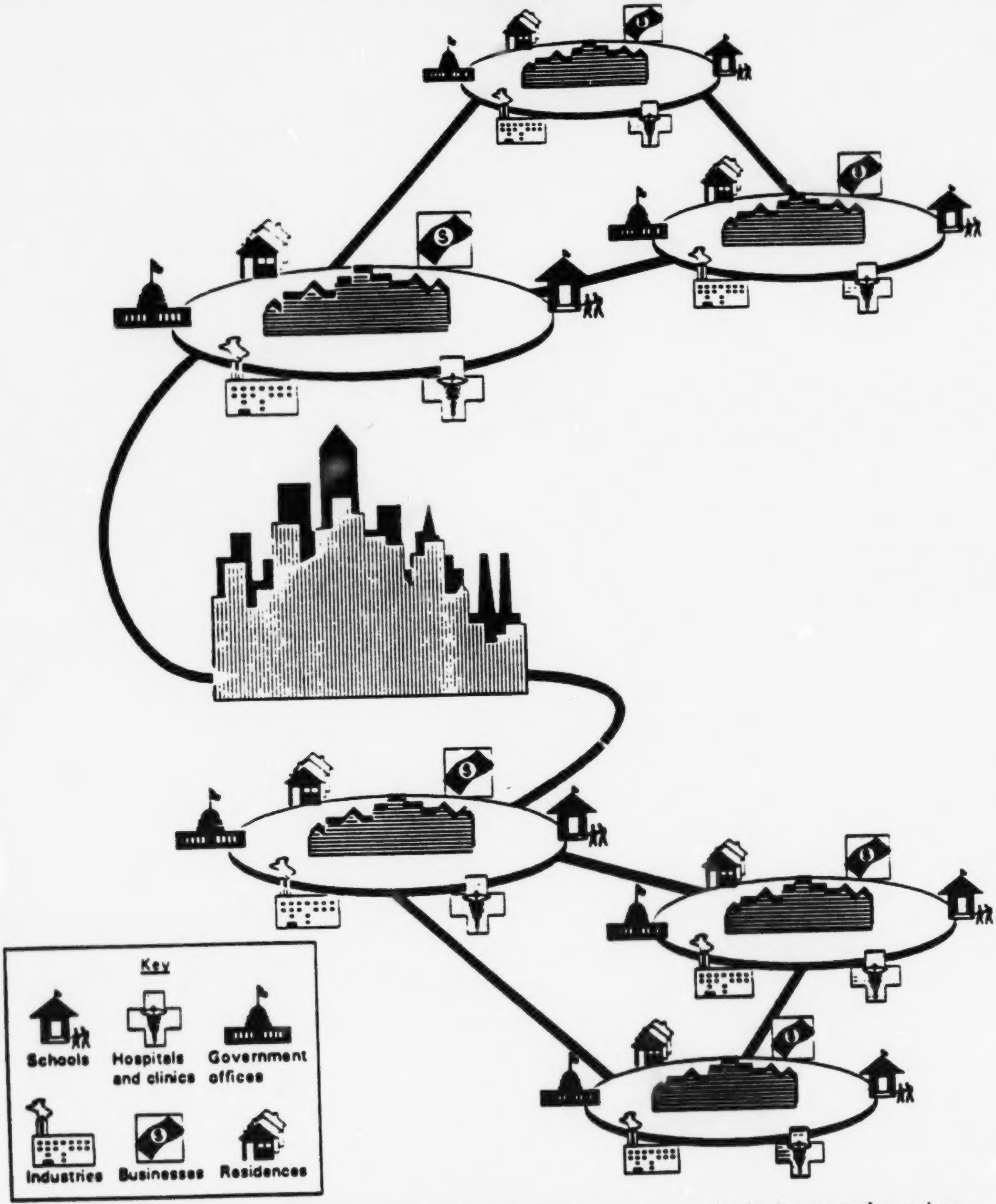
Rural Area Networks (RANS)

Rural communities differ in the telecommunications infrastructure currently available to them. Some rural communities, because of their size or location, may have ready access to a range of telecommunication channels and long distance carriers. However, many communities do not and, as the Congressional Office of Technology Assessment has noted, many rural communities may not be able to afford more than one modern high capacity telecommunications network.

The Congressional Office of Technology Assessment has recommended the creation of Rural Area Networks (RANS). In contrast to Local Area Networks (LANS), which are built around functional lines, RANs would be configured around the geographic boundaries and needs of an entire rural community. Aggregating the telecommunication needs of health providers, educational institutions, businesses, and local government, would enhance economies of scale and scope, as well as provide greater leverage in the marketplace for the community and its diverse sectors.

The development of a such a network is an option that rural communities may want to explore. New organizational arrangements as well as regulatory flexibility would be required for this strategy to work. Whether or not that option is feasible for a community, the planning for telecommunications infrastructure is critical. A troubling phenomenon seen in many rural communities is the lack of coordinated planning among different potential users (e.g., education, health care, and business). Telecommunication technologies are increasingly being deployed to meet individual sector needs, rather than being visualized and planned for as an

Figure 5--Rural Area Networks


Key
Schools
Hospitals and clinics
Government offices
Industries
Businesses
Residences

A Rural Area Network would be designed to foster the deployment of advanced technology to rural areas in an economically viable manner by pooling the communication needs of a community's many users--especially the businesses, educational institutions, health providers, and local government offices.
SOURCE: Office of Technology Assessment, 1991.

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infrastructure element of the community (such as roads, or water or sewage plants). The result is that in some rural communities, different telecommunication systems serve different sectors, a situation that may not be the most cost-effective, viable situation for a community as a whole.[13]

The opportunity exists for rural health professionals, and others active in rural health, to play a critical role in not only enhancing the overall success of a health facility, but also the overall economic development and health of a community. To address the telecommunication infrastructure needs of their rural communities, health professionals can help foster needed new partnerships: between telecommunication experts and rural health and rural development experts, between rural communities and their state regulators, and between technical experts and the rural communities whose future is being decided.

For example, rural health providers can bridge the gap between regulators who rarely consider multifaceted economic development goals when making regulatory policy, and other health providers, educators, and local governments who often are not aware of what is at stake for them in the regulatory process. An opportunity now exists for educational, health care, and rural development individuals to influence important telecommunications policy decisions by working with regulatory agencies. Regulatory agencies are all public agencies and, as the education community has begun to learn, can be influenced by requests that serve the public good.

Superhighways

One reads more and more in the popular press about the new "electronic superhighway" -- particularly in its relation to a new world of video entertainment and interactive services. Receiving less attention, but particularly important to health care and education, is the proposed information superhighway -- the National Research and Education Network (NREN). As proposed, the NREN will be an interconnected gigabit computer network system for research and education -- in essence, a greatly expanded and enhanced Internet.

The NREN is the electronic networking component of the federal government's "High Performance Computer and Communications Initiative" (HPCC). The HPCC is an interagency federal research and development effort in high performance computers and high-speed communication. In FY 1993, over $800 million was budgeted across agencies for this initiative, part of a total budget of $5 billion for the next four years.

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[13] Deaconess Medical Center in Billings recently launched an innovative demonstration telemedicine project in Eastern Montana that also addresses rural community development. For the first six months of the demonstration period, the network will be available at no cost for business and community service purposes.

The Administration has endorsed applying the technologies developed under the HPCC initiative to health care and education in two recent reports -- "A Vision of Change for America," a report that accompanied President Clinton's address to the Joint Session of the Congress, and a February 22, 1993 White House technology policy paper. Applications proposed include linking schools, hospitals, libraries, and other entities to the high-speed network; supporting technology to provide health care providers with access to relevant medical information and literature; and developing collaborative technology to allow providers in remote locations to provide real-time treatment of patients, etc.

Rural health providers can work to ensure that the proposed information superhighway -- the National Research and Education Network (NREN) -- does not bypass rural America. As can be seen in the Pacific Northwest Pilot Connections project, the NREN has the potential to enhance access for rural health providers to biomedical and other information databases -- access that can maintain and enhance the quality of care in rural health facilities and decrease the isolation of rural health professionals.

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To obtain information on libraries in one's area that provide Loansome Doc service, contact your Regional Library of the National Network of Libraries of Medicine (NN/LM) at 1-800-338-7657.

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The Medical College of Georgia, Robert B. Greenblatt, M.D. Library maintains a telemedicine database. Information about the database and service charges can be obtained by calling the library at 706-721-3667.

To obtain copies of the four volume telemedicine report jointly prepared by the Kansas Department of Health and Environment and the Kansas Hospital Association contact:

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GLOSSARY OF TELECOMMUNICATIONS TERMS

Amplifier - electronic devices, spaced at intervals throughout a cable television system, used to boost the strength of the cable signal as it passes from the headend to the subscriber. In coaxial cable systems, amplifiers are needed approximately every 1,500 feet. Amplifiers are also used in twisted copper pair telephone lines.

Analog - a continuously varying electrical signal in a shape of a wave. It is represented by continuous wave forms that vary in size and number as the source of the information varies. The variations in voice, loudness or pitch that a user hears at the other end reflects differences or fluctuations in the electrical current.

Asynchronous communication - two-way communication in which there is a time delay between when a message is sent and when it's received (e.g., electronic mail and voice mail).

Audiographic teleconferencing - refers to the transmission of graphic and text information over a narrowband telecommunications channel such as a telephone line or a sub-carrier.

Audio-teleconferencing - two way electronic voice communication between two or more people at two or more locations.

Backbone Network - a high speed transmission facility (e.g., optical fiber) designed to interconnect lower speed distribution channels.

Backhaul - a term used to describe the transmission of a signal (normally video) from the end of a microwave or broadcast system to a central point.

Bandwidth - a measure of the information carrying capacity of a communications channel; the higher the bandwidth, the greater the amount of information which can be carried.

Baud - a unit of digital transmission signalling speed of information transmission. It is used to describe the rate of information flow. Given in bits per second (bps) the rate is the highest number of single information elements (bits) transferred between two devices (such as modems or fax machines) in one second.

BBS (Bulletin Board Service) - a computer service that allows remote users to access a central "host" computer to read and post electronic messages.

Bit - stands for binary digit. It is the smallest possible unit of information making up a character or a word in digital code, and is represented as either "on" or "off" by the numbers "0" or "1." An electronic string of bits represents letters and symbols.

BITNET - The acronym for Because It's Time Network, an international electronic network. BITNET, privately owned by a consortium of U.S. colleges and universities, has about 2,500 host computers located primarily at universities.

Bridge - a device which is used to interconnect three or more telecommunications channels such as telephone lines, to permit simultaneous, two-way communication among all points which have been interconnected.

Broadband - communications which are capable of carrying a wide range of frequencies. Broadcast television, cable television, microwave, and satellite are examples of broadband technologies.

Cable television - a transmission system which distributes broadcast television signals and other services by means of coaxial cable. Residential cable subscribers are connected by means of cable to a central community antenna (CATV), which picks up signals from satellites for community distribution.

C-Band - a category of satellite transmission in the 6 GHz range. C-Band transmission generally requires a large antenna, or "downlink dish" because of its use of longer wavelength frequencies when compared to other transmission systems such as Ku-Band.

Central Office (Switching Office) - a local telephone company facility that houses the switching system and related equipment needed to interconnect telephone calls for customers in the immediate geographic area. Every LATA must have at least one central office.

Channel - a radio frequency assignment made according to the frequency band being used and the geographic location of the send/receive sites.

Coaxial cable - a metal cable consisting of a conductor in the form of a tube which can carry broadband signals by guiding high frequency electromagnetic signals. It is used for voice, data, and video.

Codec - a term used for a "code/decode" electrical device which converts an analog electrical signal into a digital form for transmission purposes. It is generally used to transform video signals into digital form for transmission over digital transmission systems. Generally speaking, this digital information must be reconverted into analog form at its point of reception.

Common carrier - A telecommunications company that is regulated by government agencies and offers communications relay services to the general public via shared circuits, charging published and non-discriminatory rates.

Compressed video - video images which have been processed to remove redundant information, reducing the amount of bandwidth needed to capture the necessary information so that the information can be sent over narrowband carriers such as a T1 telephone line.

Computer conferencing - group communications through computers, or the use of shared computer files, remote terminal equipment and telecommunications channels for two-way, real-time group communication.

Conference call - a telephone call which, by making use of a bridge, connects more than two individuals at geographically distinct locations for simultaneous conversation.

CPR (Computed-based Patient Record) - the term for the computer-generated (electronic) patient record that is being developed.

Customer Premises Equipment (CPE) - devices ranging from simple telephones to computers to TV monitors that are located at a customer's location and are used to send or receive information over a telephone network.

Digital - discrete signals such as those represented by means of bits (which are either "on" or "off") as opposed to continuously variable analog signals. Used in both electronic and light-based systems, digital signals transmit audio, video, and data as bits. Digital technology allows communications signals to be compressed for more efficient transmission.

Direct Broadcast Satellite (DBS) - a satellite designed with sufficient power so that inexpensive earth stations, or downlinks, can be used for direct residential reception.

Direct Digital Imaging - involves the direct capture of digital images (e.g., an MRI) so that they can be electronically transmitted. This is in contrast to an x-ray that is first made into a film and then photographed for digitization to send or store.

Dish - a parabolic antenna that is the primary element of a satellite earth station, or downlink.

Downlink - the path, or link, from the satellite to earth stations which receive its signals. The term is frequently applied to a parabolic antenna that receives signals from a satellite. It is often referred to as: a dish, a terminal, an earth station, or a TVRO (television receive only).

DS1 - SEE T1

DS3 - SEE T3

Earth station - The ground equipment, including a dish and other electronics components needed to receive and/or transmit satellite telecommunications signals. An "uplink" is used for sending information to a satellite for distribution to various earth receiving stations, while a "downlink" is used to receive such information.

EDI (Electronic Data Interchange) - the sending and receiving of data directly between trading partners without paper or human intervention.

Equal Access - ability to choose between the different long distance carriers. In rural areas, some local exchange carriers are still serviced by only one long distance carrier.

Facsimile (Fax) - a device which electronically transmits and reproduces documents over telephone lines.

Fiber Optics - hair-thin, flexible glass rods encased in cables that use light to transmit audio, video, and data signals.

Footprint - the geographic region on the earth underneath a satellite which is in the appropriate range to receive that satellite's information.

Freeze frame - one method of transmitting still images over standard telephone lines. A single image is transmitted every 8-to-30 seconds. This is also referred to as slow scan.

Frequency - the rate at which an electromagnetic signal alternates. It is a term used with analog signals, and is reported in Hertz.

Full duplex - a communication channel over which both transmission and reception are possible in two directions at the same time. A standard telephone line is a full duplex system since people on either end of the connect can simultaneously speak while listening to sounds coming from the other end.

Full-motion video - a standard video signal that can be transmitted by a variety of means including television broadcast, microwave, fiber optics, and satellite. Full-motion video traditionally requires 6 MHz in analog format and 45 Mbps when encoded digitally.

Gb (Gigabit) - one billion bits of information - usually used to express a data transfer rate (e.g., 1 gigabit/second = 1Gbps). The bandwidth of optical fiber is often in the gigabit or billion-bits-per-second range.

Geostationary orbit - describes the orbit of a satellite whose position relative to the earth's surface is constant so it appears to hover over one spot on the earth's equator.

GHz (Gigahertz) - one billion cycles per second. It is a measurement of analog signal transmission.

Half duplex - a communication channel over which both transmission and reception are possible but only in one direction at a time.

HDTV (High Definition Television) - an advanced television system that produces video images as clear as high-quality photography.

Hertz - a unit of frequency equal to one cycle per second.

HPCC (High Performance Computing and Communications Program) - the HPCC initiative is a federal coordinated, interagency research and development effort designed to accelerate the availability and utilization of the next generation of high performance computers and networks.

Independent Telephone Company - a local exchange carrier that is not part of the Bell system of operating companies (BOCs). In rural areas, many of the independent telephone companies are cooperatives.

Informatics - the application of computer science and information science to the management and processing of data, information, and knowledge.

INTERNET - the largest international computer network. It is a network of computer networks linking computers from colleges and universities, government agencies, institutions, and commercial organizations worldwide. Owned by the U.S. government, it is used primarily for research and educational purposes.

ISDN (Integrated Services Digital Network) - a digital telecommunications channel that allows for the integrated transmission of voice, video, and data; a protocol for high-speed digital transmission. (see Table 2)

ITFS (Instructional Television Fixed Service) - a non-broadcast television service that is typically used for closed-circuit instructional applications. It requires special antennas and converters to translate signals for viewing.

IXC (Interexchange Carrier) - a telephone company such as AT&T, Sprint, or MCI that carries long distance calls. The IXCs are authorized by the FCC to carry interLATA, interstate traffic and can be authorized by state PUCs to carry interLATA, intrastate traffic. Also known as Long Distance Carriers.

Kbs - stands for kilobits (1000 bits) per second. It is a way of reporting the rate of transmission of digital information per second.

Ku-Band - frequencies in the 11-to-14 GHz band used to send and receive signals to and from satellites. Being somewhat more narrow than C-Band transmissions, the dish needed to receive these signals is smaller; Ku-Band tends to be somewhat less expensive than C-Band for this reason.

LANs (Local Area Networks) - data communication networks that are fairly limited in their reach - e.g., the premises of a building or a campus. They are private networks that facilitate the sharing of information and computer resources by the members of a group.

LATA - stands for Local Access Transport Area. These are local telephone service areas created by the divestiture of the regional Bell operating companies (RBOCs) formerly associated with AT&T.

LDC (Long Distance Carrier) - see IXC (Interexchange Carrier)

Leased lines - a line rented from a telephone company for the exclusive use of a customer. May also be called a dedicated line.

LEC (Local Exchange Carrier) - a telephone company that carries local calls.

Low-Altitude Satellites - satellites that orbit the Earth at lower altitudes than the geosynchronous satellites and cannot maintain a constant position above the Earth. Thus, they are only accessible when they come into view of the receiving dish, two or three times a day for a few minutes at a time.

Mbps - Megabits per second, or one million bits per second.

Medical informatics - the combination of computer science, information science, and the health sciences (medicine) designed to assist in the management and processing of data to support the delivery of health care.

Microwave - high frequency radio waves used for point-to-point communication of audio, video, and data signals. They can be simplex (omnidirectional) or duplex. The microwave spectrum is generally above 2 GHz. Microwave transmission requires line of sight transmission between sending and receiving antennas.

Modem - a modulator/demodulator. This device converts digital information into analog form for transmission over a telecommunications channel, and reconverts it to digital form at the point of reception.

Multiplexer - equipment which transmits two or more lines of voice, data, or video information over a single channel. For example, a multiplexer enables a single T1 telephone line to be split into a number of different "channels" to allow for multiple applications to be carried along the same T1 line.

Narrowband - a telecommunications medium, such as copper wire or part of a coaxial cable channel, that uses (relatively) low frequency signals. Generally speaking, narrowband transmissions go up to 1.544 Mbps.

Network - a set of nodes, points, or locations which are connected by means of data, voice, and video communications for the purpose of exchanging information.

NREN (National Research and Education Network) - the international, interconnected gigabit computer system network proposed under the HPCC initiative. The term "Interagency Interim NREN (IINREN) is now being used to describe the network.

NSFNET (National Science Foundation Network) - NSFNET is the high-speed network that connects mid-level regional computer (Internet) networks to support scientific research facilities throughout the country.

Packet Switching - the process of transmitting digital information by means of addressed packets - which include data, call control signals, and error control information - so that a channel is occupied only during the transmission of the packet. In contrast, data sent using modems occupies a circuit for the entire duration of the transmission, even when no data is actually traveling over the lines. Using packet switching, the various packets of information can travel along different routes on the network, allowing the carrier to optimize its network capacity.

PBX - stands for Private Branch Exchange, a computerized version of the telephone switchboard but with an expanded range of voice and data services. It operates as a private telephone exchange that serves a particular organization and has connections to the public telephone network.

POP (Point of Presence) - The point at which an interexchange carrier's circuits connect with local circuits for transmission and reception of long distance phone calls.

Port - a circuit in an electronic device for the input or output of signals.

PSTN (Public Switched Telephone Network) - the public telephone network.

Radio technology - used for telecommunications and broadcast services. Used for radio waves in frequencies that are distinct from those assigned to microwave services.

RANs (Rural Area Networks) - as conceptualized by the U.S. Congress, Office of Technology Assessment, RANs would be shared-usage networks, configured to include a wide range of users in rural communities - such as educational, health, and business entities.

RBOC (Regional Bell Operating Company) or Regional Holding Company - one of the seven regional companies formed by the AT&T divesture (Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell and U.S. West. The BOCs (Bell Operating Companies) are grouped under the seven regional holding companies.

Repeater - a bi-directional device used in channels to amplify or regenerate signals.

RF - stands for radio frequency. Radio frequencies are electromagnetic signals which range from microwave to radio in length.

Routing - The assignment of a communication path by which a telephone call will reach its destination.

RS-232-C - A standard interface between a piece of equipment and a telephone circuit.

Rural Radio Service - the use of certain frequencies, distinct from those in microwave toll service, used to provide wireless telephony in rural areas. It can support the transmission of both analog and digital signals. It provides short-haul telecommunications, and requires different power, transmission, and reception capabilities and devices.

Satellite - an electronics retransmission device serving as a repeater, normally placed in orbit around the earth in geostationary orbit for the purpose of receiving and retransmitting electromagnetic signals. It normally receives signals from a single source and retransmits them over a wide geographic area, known as the satellite's "footprint."

Slow scan video - a device that transmits and receives still video pictures over a narrow telecommunications channel, such as standard telephone lines.

SMDS - (Switched Multimegabit Data Service) - SMDS is a high-speed, fast packet-switched service provided in a campus, or ring, type arrangement situated within a 50-mile radius.

SS7 (Signaling System 7) - a recent development in control systems for the public telephone network. It allows telephone company computers to communicate with each other, making telephone call processing faster and more efficient and enabling more services to be made available to consumers.

Switch - a mechanical or solid state device that opens or closes circuits, changes operating parameters, or selects paths or circuits on a space or time division basis.

Switched Network - a type of system where each user has a unique address (e.g., a phone number) which allows the network to connect any two points directly.

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T1 (also known as DS1) - refers to a digital carrier capable of transmitting 1.544 Mbps of electronic information. It is the general term for a digital carrier available for high volume voice, data, or compressed video traffic. T1 is a standard for transmission that is accepted in North America. **Fractional T1 or sub T1** tariffs are rates for bandwidths between 56 Kbps and 1.544Mbps, such as 384Kbps = 1/2 a T1.

T3 (also known as DS3) - a carrier of 45 Mbps bandwidth. One T3 channel can carry 28 T1 channels.

T-carrier - a series of transmission systems using pulse code modulation technology at various channel capacities and bit rates to send digital information over telephone lines, including optical fiber lines, or another transmission medium.

Telecommunications - the use of wire, radio, optical, or other electromagnetic channels to transmit or receive signals for voice, data, and video communications.

Teleconferencing - interactive electronic communication between two or more people at two or more sites which make use of voice, video, and/or data transmission systems: audio, audiographics, computer, and video systems.

Telemedicine - the use of telecommunications for medical diagnosis and patient care.

Teletext - a broadcasting service using several otherwise unused scanning lines (vertical blanking intervals) between frames of TV pictures to transmit information from a central database to receiving television sets.

Terrestrial Carrier - a telecommunications transmission system using land-based facilities (microwave towers, telephone lines, coaxial cable, fiber optic cable) as distinguished from satellite transmission.

Translator - a broadband network operation. A translator is a device which is located in a central retransmission facility to filter incoming microwave signals and retransmit them in a higher frequency band.

Transmission Speed - the speed at which information passes over the line; defined in either bits per second (bps) or baud.

Transponder - a microwave repeater (receiver and transmitter) in a satellite that receives signals being sent from earth, amplifies them, and sends them back down to earth for reception purposes. Domestic communication satellites use either 12 or 24 transponders, equivalent to a single channel, which usually have a 36 MHz bandwidth.

Trunk - a large capacity, long distance channel used by common carriers to transfer information between its customers.

Turn-key system - a telecommunications system in which all components and installation services needed for operational teleconferencing have been provided by a single vendor or contractor.

TVRO (Television Receive Only) - an earth station capable of receiving satellite TV signals but not of transmitting them; a "downlink."

Twisted Pair - cable made of a pair of insulated copper wires wrapped around each other to cancel the effects of electrical noise. It can transmit voice and data and, in some cases, low-grade video. It is the most prevalent type of medium in PSTN's local loops. The wire-pair sizes typically range from 19-to-26 gauge. Cables with as many as 2,700 pairs of 26-gauge wire are used in urban areas.

Uplink - the path, or link, from a transmitting earth station tothe satellite. The term is frequently applied to a transmitting earth station.

Voice grade channel - a telephone circuit of sufficient bandwidth to carry signals in the voice frequency range of 300-to-3400 Hertz.

Voice Switching - an electrical technique for opening and closing a circuit, such as changing from one microphone to another microphone or from one video camera to another video camera, in response to the presence or absence of sound.

VSAT (Very Small Aperture Terminal) - a type of satellite dish (1.8-2.4 meters in diameter). Used primarily for data transmissions (low speed to high speed). Can send and receive voice, data and video signals if enhanced. VSATs can transmit over wide areas by relaying to satellites in geosynchronous orbit.

WANs (Wide Area Networks) - data communication networks that provide long-haul connectivity among separate networks located in different geographic areas.

WATS (Wide Area Telephone Service) - a flat rate or measured bulk rate long distance service provided on an incoming or outgoing basis. WATS permits a customer, by use of an access line, to make telephone calls to any dial-able telephone number in a specific zone for a flat or bulk monthly rate using an 800 number.

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TABLE 1

Transmission Channels

Channel	Bandwidth/ Transmission Speeds	
Twisted-pair Copper	4KHz (64Kbps) *	One twisted copper pair transmitting at 4KHz can carry 48 calls. It originally required a 64Kbps channel to send a digitized voice call; today a voice grade call can require as little as 8Kbps to 16 Kbps. A conventional 3" thick cable contains 1,200 pairs of copper wires.
Co-axial Cable	140 Mbps	Coaxial cable consists of up to 22 coaxial conductors. (A coaxial conductor is a copper tube as big around as a pencil; a copper wire is held in the tube's center by plastic insultators.) Coaxial cable is used to transmit video, voice and data. A pair of coaxial tubes can carry up to 13,200 telephone calls. Cable TV systems use coaxial cable to carry TV signals into subscribers' homes. Some TV networks use coaxial cable to send their programs to affiliated stataions for broadcasting to viewers. Coaxial cable is also used in LANS. Coaxial cable is capable of carrying two-way signals, but most systems are currently designed for uni-directional use.
Optical Fiber		Optical fiber is used by telephone companies for long distance trunk lines and by cable TV companies to carry TV signals into the homes of subscribers.
	565 Mbps	565 Mbps is a commonly used optical fiber transmission speed. At 565 Mbps a single fiber pair can carry more than 8,000 voice channels. Ninety-six fibers (or 48 fiber pairs) can carry more than 384,000 voice channels.
	1.2 Gbps	At 1.2 Gbps, a single fiber pair can carry 18,816 voice channels.
	1.7 Gbps	At 1.7 Gbps, a single fiber pair can carry 24,192 voice channels.
	3.4 Gbps	3.4 Gbps is the fastest commercial transmission speed available in the early 1990s.
Microwave Relay Systems +		Microwaves, a type of electromagnetic wave, are short, super high frequency radio waves that travel in straight lines. Microwave systems can transmit either analog or digital signals. Commercial terrestrial fixed microwave systems operate at frequencies between 1.7 GHz and 23 GHz. The amount of bandwidth available varies from system to system.
	45 Mbps	Some phone company microwave systems use 45 Mbps channels. This is equivalent to 28 T1 circuits or channels.
Microwave ITFS	6MHz per channel in the 2.5 GHz band	Instructional Television Fixed Service is a special band of the microwave frequencies reserved for educational purposes by the FCC.

Radio Relay Systems	AM band - 535-1705 KHz FM band - 88-108 MHz	Radio waves, used for radio and TV broadcasting and for telecommunications, are high frequency electromagnetic waves that are longer than microwaves. They can transmit either analog or digital signals. Radio broadcasting waves follow the curve of the earth, in contrast to microwaves which travel in straight lines. Frequencies assigned for use by radio systems are distinct from those assigned to microwave toll service. The AM band of frequencies ranges from 535 - 1705 KHz; the FM band from 88 - 108 MHz. A single FM radio channel may require only 150 KHz; an AM channel only 10 KHz.
Digital	180 Mbps	A digital radio system used for telecommunications is capable of transmitting 4 DS-3 channels or 180 Mbps.
Satellite	C: 4GHz/6GHz Ku: 12GHz/14GHz Ka: 30 GHz/20GHz	Satellites function as relay stations in the sky -- satellite transponders receive signals from an uplink and transmit them back to Earth. The transponders generally operate in two frequency bands: C-band and Ku-band. Until recently, most transponders had a 36MHz bandwidth and could transmit 6 TV broadcast channels of 6MHz each. With new compression technologies, transponders can carry more channels. The C or Ku band GHz/GHz designation refers to the frequency bands in which signals are transmitted, not to the bandwidth of the signals being transmitted. For example, in the Ku-band, the channel bandwidth used to transmit analog video signals might range from 34-54 MHz. Ka-band is the newest of these technology.
Terrestrial Broadcast Systems for Television	6 MHz analog or 45 Mbps digital	TV signals are electromagnetic waves that fall within the radio frequency spectrum. TV signals consist of modulated video and audio carrier waves. TV signals can be received clearly up to a distance of 75 - 150 miles; to be sent further, they must be converted to microwaves. The group of frequencies over which one TV station broadcasts is known as a channel. 68 channels are available in the United States and Canada; Channels 2-13 are VHF channels (very high frequency) and Channels 14-69 are UHF channels (ultrahigh frequency). A TV channel broadcasting in analog occupies a band of frequencies that is 6MHz wide.
High Definition Television (HDTV)	1.3 Gbps	High Definition Television (HDTV) is an advanced television system that produces video images as sharp as high-quality photographs. Work is underway to develop compression technology to enable HDTV to be transmitted by a bandwidth of 6 MHz.

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* The actual capacity of twisted copper pair will vary with distance. That is, it varies directly with gauge and inversely with distance such that a 24 gauge twisted pair copper wire can carry 1.5 Mbps of traffic to about 6 feet or 2.4 Kbps to about 10 miles.

+ Radio frequency bands range from 15KHz to 300GHz. Within this, the microwave frequency bands range from 300MHz to 300GHz.

TABLE 2

Compression Standards and Comparisons

1 bit - 1 b	- Binary digit. The smallest possible unit of information making up a character or a word in digital code, represented either as "on" or "off" by the numbers "0" or "1."
1,000 bits - 1 Kbps	- *one thousands bits per second or a kilobit/second*
56,000 bits - 56 Kbps	- Compressed video can be transmitted at 56 Kbps. 56 Kbps is sometimes offered on a "dial-up" basis.
64,000 bits - 64 Kbps	- DS-0 capacity. 64 Kbps or DS-O is the basis of a digital channel.
384,000 bits - 384 Kbps	- 1/4 of a T1 channel or a "fractional T1" or a "sub-T1." Using new codecs meeting a new international standard, quality compressed video can be transmitted at this speed.
1,000,000 bits - 1 Mbps	- *one million bits per second or a megabit/second*
1,544,000 bits - 1.54 Mbps	- T1 or DS-1 capacity. This is a common transmission speed for compressed interactive video. It is also the transmission standard for Primary ISDN.
2,140,000 bits - 2.14 Mbps	- The transmission speed of optical fiber in 1978.
45,000,000 bits - 45 Mbps	- T3 or DS-3 capacity. This transmission speed supports full motion video and is used in telemedicine applications such as fluoroscopy.
155,000,000 bits - 155 Mbps	- The transmission speed for ATM (Asynchronous Transfer Mode) or fast packet switching.
274,000,000 bits - 274 Mbps	- T4 or DS-4 capacity.
545,000,000 bits - 545 Mbps	- The common transmission speed for commercial optical fiber. At 545 Mbps a single fiber pair can carry 8,000 voice channels.
1,000,000,000 bits - 1 Gbps	- *one billion bits per second or a gigabit/second*
1,300,000.000 bits - 1.3 Gbps	- HDTV requirements without compression.
2,000,000,000 bits - 2 Gbps	- The transmission speed of optical fiber speed in 1990.
3,400,000,000 bits - 3.4 Gbps	- The fastest commercial transmission speed for optical fiber in the early 1990s.

Compression Standards and Comparisons (cont.)

T or DS Transmission Standards

Bandwidth capacity can be designated by using standards, e.g. T1. These standards indicate how much information can be transmitted per second over the channel. It is helpful to recognize that a T1 "channel" is not necessarily an actual physical conduit or line, such as a cable, but is an amount of information that can be transferred per second by a range of telecommunications circuits or channels. For example, T1 amounts of information can be transmitted over wireline channels (i.e., enhanced twisted copper pair, co-axial cable, optical fiber) or over radio wave channels using digital radio or terrestrial microwave or satellite.

DS-0 = 64,000 bits per second (64 Kbps). This is the basis of all digital network standards.
T1 or DS-1 = 1,544,000 bits per second (1.544Mbps). This is 24 64Kbps channels (23 for audio, video and data; 1 for signalling; and 8000 bits for framing.)
T2 or DS-2 = 6,300,000 bits per second (6.3Mbps).
T3 or DS-3 = 45,000,000 bits per second (45Mbps). This provides full-motion video for telemedicine applications and is the speed of Switched Multimegabit Data Service (SMDS).

ISDN Protocols or Transmission Standards

Like T carrier standards, ISDN designations are also standards or protocols that have been agreed upon for transferring information over channels. (Protocols are agreed upon standards that allow devices to communicate with each other.) Standards for ISDN are being established by the Consultative Committee for International Telephone and Telegraph (CCITT). All of the standard ISDN interfaces are based on a multiple of a digital voice grade channel - i.e., 64 Kbps. ISDN standards vary internationally; in Europe primary ISDN is 30 64Kbps channels and 1 64Kbps signalling channel. ISDN systems require digital input and output devices.

ISDN Basic Service = 144 Kbps = 2 64Kbps channels + 1 16Kbps channel for signalling. [2B + 1D]
ISDN Primary Service = 1.544 Kbps = 23 64Kbps channels + 1 64Kbps channel for signalling (equivalent of T1). [23B + 1D]
ISDN Broadband Service = (150Mbps) Dynamically configurable channels at rates up to 150 Mbps using optical fiber. The broadband standards are under discussion, with 45 Mbps serving as an interim standard.